TRENDS AND OUTLOOK OF NATURAL RESOURCE USE IN WEST ASIA

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Lead authors: Viktoras Kulionis, Stephan Pfister, Duy Nong, Subashini Perera, Yingying Lu and Heinz Schandl.

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PREFACE

In a region suffering from water scarcity, holding the world's largest reserves of crude oil, and being the largest producer of fossil fuels, identifying sustainable pathways of growth, while enhancing well-being, is crucial. Decoupling economies from resource consumption while global demand for such resources continues to grow is challenging, but key to addressing the triple planetary crises of nature.

Several countries in West Asia are increasingly stepping up their efforts to ensure a sustainable transition by introducing green growth strategies to reduce reliance on fossil fuels as well as economic diversification strategies.

In this context, we are happy to introduce the 'Trends and Outlook of Natural Resource Use in West Asia', a think piece produced under the auspices of the International Resource Panel (IRP) of the United Nations Environment Program (UNEP), in collaboration with the UNEP Regional Office for West Asia.

This report aims to provide policy makers in the region with insights on the trends and outlook for natural resource use and environmental impacts in West Asia. It has the ultimate objective of setting the bases for informing regional and country consultations on the pathways the region is to take towards a sustainable future and the coherent policies that will support such transition.

This report marks also the first attempt of translating at regional level the methodology underlying the 'Global Resources Outlook 2019' (GRO 2019), to amplify the regional perspectives from the insights of the global projections. In order to do that, the study covers the 12 countries served by the UNEP Regional Office for West Asia: Kingdom of Bahrain, Republic of Iraq, The Hashemite Kingdom of Jordan, State of Kuwait, Republic of Lebanon, State of Palestine, State of Qatar, Sultanate of Oman, Kingdom of Saudi Arabia, Syrian Arab Republic, United Arab Emirates and the Republic of Yemen.

We wish this report will support and inspire countries in West Asia to further developing their ambitions towards sustainable pathways.

This landmark report would not have been possible without the extraordinary dedication of the colleagues from the International Resource Panel and the UNEP Regional Office for West Asia, and the support of the Global Opportunities for Sustainable Development Goals initiative (GO4SDGs).

Izabella Teixeira and **Janez Potocnik**
Co-chairs
International Resource Panel

Sami Dimassi
UNEP Representative
and Regional Director
for West Asia

GLOSSARY

DPSIR framework: the DPSIR (Drivers-pressures-state-impacts-response) framework aims to provide a step-wise description of the causal chain linking economic activity (the drivers), the pressures (such as emissions of pollutants), changes in the state of the environment (including land cover change) and impacts (diminished human health and others). This then leads to a societal response aimed at adapting those driving forces to reduce impacts. It must not be understood as a reactive governance approach that waits for irreversible changes to the environment before responding, but rather an approach that supports preventative action and can be used as an analytical tool for linking human-nature systems in future modelling to help steer a transition.

Circular economy: an economy in which the value of products, materials and resources is maintained in the economy for as long as possible, and waste generation is minimized. This contrasts with a "linear economy", which is based on the "extract, make and dispose" model of production and consumption.

Consumption-based accounting/Consumption perspective (CBA): the consumption perspective allocates the use of natural resources, or the related impacts throughout the supply chain, to the region where these resources, incorporated in various commodities, are finally consumed by industries, governments and households. It is the domestic impact, plus the impact of imports, and minus the impact of exports.

Decoupling (absolute/relative): this is when resource use or some environmental pressure either grows at a slower rate than the economic activity that is causing it (relative decoupling) or declines while the economic activity continues to grow (absolute decoupling).

Domestic (material) extraction (DE): the direct, gross physical extraction of materials within a country's territory (production perspective).

Domestic material consumption (DMC): the quantity of materials used directly by an economy (DMC = DE + Material Imports – Material Exports).

Ecosystem services: ecosystem services are the functions and processes inherent in ecosystems and which affect human well-being. They include (a) provisioning services such as food, water, timber and fibre; (b) regulatory services such as the regulation of climate, floods, disease, waste and water quality; (c) cultural services such as recreation, aesthetic enjoyment and spiritual fulfilment; and (d) supporting services such as soil formation, photosynthesis and nutrient cycling (MEA 2005).

Impact: the term is used by the Resource Panel to refer to negative environmental impacts. These are the unwanted side-effects of economic activities and can take the form of a loss of nature or biodiversity, as well as diminished human health, welfare or well-being. Impacts can be intentional (e.g. land conversion impacts habitat change and biodiversity) or unintentional (e.g. humans may inadvertently alter environmental conditions such as the acidity of soils, the nutrient content of surface water, the radiation balance of the atmosphere and the concentrations of trace materials in food chains). Impacts occur across all stages of the life cycle, from extraction (i.e. groundwater pollution) to disposal (i.e. emissions). Impacts in a life cycle assessment (LCA) context correspond to pressures in the Drivers-pressures-state-impact-response framework.

Input-output (IO) method: input-output tables describe the interdependence of all production and consumption activities in an economy. In an input-output model, the economy is represented by industry sectors (including resource extraction, processing, manufacturing and service sectors) and final demand categories (including households, government, investment, export and stock changes). Integrating information on emissions and resource use caused by sectors and by final demand allows environmentally extended IO tables (EEIOT) to be provided; these can be used to calculate environmental pressures induced by production sectors or final demand categories in a similar way to value added or labour.

Material resources: metals, non-metallic minerals, biomass and fossil fuels.

Material footprint (MF): a nation's MF fully accounts for material extraction in other countries used for domestic consumption in the nation of interest (consumption perspective).

Material intensity (MI): indicates efficiency of material use (MI = DMC / GDP).

Material-related impacts: environmental impacts and socioeconomic benefits (value added, workforce) related to the extraction and processing of material resources (including the upstream supply chain, such as electricity generation and transport).

Net traded materials/impacts: difference between material-related impacts from a production and consumption perspective. In the case of environmental impacts, a positive value means that the material-related impacts from exports are greater than the impacts from imports (and vice-versa: environmental impacts with negative values mean that the material-related impacts from imports are greater than the impacts from exports).

Pressure: the Resource Panel uses the term "pressure" to describe environmental pressures. These are pressures evoked by human activities (commonly tied to the extraction and transformation of materials and energy) that are changing the state of the environment and leading to negative environmental impacts. Priority environmental pressures identified by the Millennium Ecosystem Assessment include habitat change, pollution with nitrogen and phosphorus, overexploitation of biotic resources such as fisheries and forests, climate change and invasive species.

Production-based accounting/Production perspective (PBA): the production perspective allocates the use of natural resources or the impacts related to natural resource extraction and processing to the location where they physically occur.

Resources: resources – including land, water, air and materials – are seen as parts of the natural world that can be used in economic activities to produce goods and services. Material resources include biomass (such as crops for food, energy and biobased materials, as well as wood for energy and industrial uses), fossil fuels (in particular coal, gas and oil for energy), metals (such as iron, aluminium and copper used in construction and electronics manufacturing) and non-metallic minerals (used for construction, notably sand, gravel and limestone).

ACRONYMS

BECCS: Bioenergy Carbon Capture and Storage

CBA: Consumption-Based Accounting

CDR: Carbon Dioxide Removal

CGE: Computable General Equilibrium

CO_2: Carbon Dioxide

DE: Domestic (Material) Extraction

GCC: Gulf Cooperation Council

GDP: Gross Domestic Product

GHG: Greenhouse Gases

GTEM-Resource: Global Trade and Environmental and Resource Model

Gt: Gigatonnes

GTAP: Global Trade Analysis Project

IRP: International Resource Panel

ISIC: International Standard Industrial Classification of All Economic Activities

Micro: A unit denoting a factor of one millionth, that is 10^{-6} (or 0.000001)

PBA: Production-Based Accounting

PDF: Potentially Disappeared Fraction of species.

Pico: A unit denoting a factor of one trillionth, that is 10^{-12} (or 0.000000000001)

SDG: Sustainable Development Goals

SSP2: Shared Socioeconomic Pathway 2

UAE: United Arab Emirates

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I OVERVIEW AND KEY FINDINGS

1.1 NATURAL RESOURCE USE

The world economy has been facing increasing problems caused by a range of factors including land degradation, water shortages, natural resource depletion, biodiversity loss, pollution, and other consequences of climate change. These effects are increasing due to the rapid expansion of production to meet the demand driven by growing populations and economies, and their associated investments in infrastructure. This socioeconomic development has speeded up natural resource extraction rates and material demands, putting huge pressure on our planetary boundaries.

Global material demand grew substantially from 27.1 billion tonnes in 1970 to around 92 billion tonnes in 2017 (IRP 2019a). Consequently, the average material demand per capita increased from 7.4 tonnes in 1970 to 12.2 tonnes in 2017 (Schandl *et al.* 2020). Most of the increase in global material extraction over this period was driven by development in Asia-Pacific and West Asia, with annual rates of increase at 4.5 per cent and 3.4 per cent, respectively (UNEP 2017). Massive material extraction and production activities have caused huge amounts of greenhouse gas (GHG) emissions to be released into the atmosphere making it a major source of air pollution (International Resource Panel [IRP] 2019a, IRP 2020). A large share of global GHG emissions is directly or indirectly linked to materials management which comes from the combustion of fossil fuels and production activities in agriculture, manufacturing and construction (OECD 2018). Emissions from the production of materials increased from 5 gigatonnes (Gt) of CO_2-equivalent (CO_2eq) in 1995 to 11 Gt in 2015, and their share of global emissions rose from 15 per cent to 23 per cent (IRP 2019a; IRP2020). As a result, the environmental impacts that occur at all stages of the supply chain have grown commensurably (Schandl *et al.* 2020).

The impact of climate change on the environment and the challenges for economic development are experienced differently across the world. A region's susceptibility to these challenges can be linked to its own natural resources, geographic and socioeconomic conditions. West Asia, an important region in the world economy, faces particularly high climate risks, such as droughts, floods, sand and dust storms. Thanks to its own massive fossil fuel reserves, the region will need to play a key role in contributing to international efforts to tackle climate change and moving the world economy in a more sustainable direction.

Economic development in most countries in West Asia depends heavily on the demand for petroleum and petroleum products (IMF 2020). In 2020, the demand for oil, for example, decreased by more than 18 per cent, leading to oil prices declining by more than 70 per cent and thereby reducing these countries' income (Deloitte 2020). Resource use is also a significant indicator in the West Asia region. Fossil fuels and metals are the most popular materials used in West Asia due to the region's oil and gas reserves, and its booming infrastructure and construction sectors, especially in the Gulf Cooperation Council (GCC) countries. From 1990 to 2014, per capita energy consumption in West Asia increased by 70 per cent due to rapid population growth and major energy subsidies (e.g. around 7.3 per cent of GDP in 2017, higher than the global average of 6.5 per cent) (UNEP 2016). The annual per capita material footprint is between 9 and 10 tonnes, equal to the values in the Asia-Pacific, Latin American and Caribbean regions, and half of those in Europe and North America, which are around 20–25 tonnes per capita) (UNEP 2016a).

Agricultural production is an important sector in the less affluent countries in the region and entails extensive irrigation activities. Agriculture in West Asia therefore contributes considerably to water scarcity due to its arid climate and high levels of production (Weinzettel and Pfister 2019).

1.2 AIM OF THE REPORT

This report was commissioned by the United Nations Environment Programme (UNEP) Regional Office for West Asia and the GO4SDGs initiative to the International Resource Panel (IRP), to analyse natural resource use and forecasts, and the environmental impacts on the 12 countries the UNEP Office for West Asia serves, namely the Kingdom of Bahrain, Republic of Iraq, Hashemite Kingdom of Jordan, State of Kuwait, Republic of Lebanon, Sultanate of Oman, State of Palestine, State of Qatar, Kingdom of Saudi Arabia, Syrian Arab Republic, United Arab Emirates (UAE) and the Republic of Yemen.

UNEP launched the Global Opportunities for Sustainable Development Goals (GO4SDGs) initiative in 2019 to accelerate the progress needed to meet the 2030 Agenda, especially for SDG 12 (Sustainable Consumption and Production) and SDG 8 (Decent work for All). The initiative builds partnerships and connects the dots to accelerate regional solutions for sustainable consumption and production and for inclusive green economies. To achieve this, the initiative shares best practices, science-based knowledge, tools and capacity development in the high-impact sectors of food, textiles, plastics and construction. The GO4SDGs focus on implementing action by supporting governments (to strengthen policy coherence), small and medium-sized enterprises (to access finance for innovation and circularity) and youth (to empower them to embrace sustainable lifestyles).

This piece of work is framed by the set of initiatives rolled out by the GO4SDGs in West Asia to enhance the knowledge and capacity of policymakers. It is the first attempt at a regional level to translate the "Global Resources Outlook 2019" (GRO 2019) approach and to test the potential of this analytical capability to inform regional and country consultations.

The aim of the report is therefore to:

- provide information on the regional environmental impacts of natural resource use;
- set out the potential outlook for natural resource use and GHG emissions from 2015 to 2060, which includes a "Historical Trends" and a "Towards Sustainability" pathway for using natural resources and the prospects of future use; and therefore
- supply the background information for undertaking regional consultations to shape relevant and targeted policies in the region aimed at the sustainable use of resources.

Appropriate policies and strategies in West Asia must play a vital role in ensuring global sustainable development pathways. Understanding the interactions between natural resource use, productivity/efficiency, GHG emissions and economic growth in West Asia is an initial step towards exploring potential pathways to decouple economic growth from resource use and environmental impacts. This would help the international community make progress on the SDG targets, such as Target 8.4 which aims progressively to improve global resource efficiency in consumption and production while decoupling economic growth from environmental degradation by 2030; and Target 12.2, which proposes to achieve the sustainable management and efficient use of natural resources by 2030.

Decoupling occurs when resource use or pressure on the environment increases at a slower rate than the economic activity causing it (relative decoupling) or declines in absolute terms while the economic activity continues to grow (absolute decoupling) (Schandl *et al.* 2020). Relative decoupling implies that the economy becomes more resource- or emissions-efficient, while the pressure on the environment is still increasing in absolute terms. Absolute decoupling is necessary to make a transition to a greener and more sustainable economy that respects the planetary boundaries.

Managing resource use and addressing different environmental challenges while attempting to maintain a healthy economy may be challenging. A systems approach can help to optimize benefits and mitigate trade-offs from natural resource use.

STRUCTURE OF THE REPORT

The report is organized into four additional chapters. Current environmental impacts are summarized by analysing GHG emissions, biodiversity loss and water stress in the West Asia region from two perspectives: a production perspective and a consumption perspective from 1995 to 2019 (Chapter 2). Drivers and pressures are presented in the form of two potential outlooks for natural resource use and GHG emissions in West Asia in 2015 to 2060 based on model-based scenario projections and analysis (Chapter 3). The responses needed to enable the transition towards sustainable pathways are set out in the last chapter (Chapter 4).

1.3 OVERVIEW OF UNEP WEST ASIA COUNTRIES

The West Asia region, as defined by the UNEP Regional Office, comprises 12 states: Kingdom of Bahrain; Republic of Iraq; the Hashemite Kingdom of Jordan; State of Kuwait; Republic of Lebanon; Sultanate of Oman; State of Palestine; State of Qatar; Kingdom of Saudi Arabia; Syrian Arab Republic; United Arab Emirates and the Republic of Yemen. In 2019, West Asia contributed about two per cent of global GDP and accounted for roughly two per cent of the global population.

The 12 Member States' economies differ considerably in terms of GDP per capita and their economic structures (**Table 1**). Saudi Arabia and the UAE are the largest economies in the region. In 2019, they contributed 37.3 per cent and 21.3 per cent of regional GDP, respectively. The West Asia region has one of the world's largest oil and natural gas reserves, but also high solar power potential due to its climate. Iraq, Kuwait, Qatar, Saudi Arabia and the UAE are major petroleum-producing countries. Qatar is the wealthiest country in the region according to GDP per capita figures and one of the wealthiest countries globally. In contrast, Syrian Arab Republic; registers the lowest per capita GDP in the region. The mining, manufacturing and utilities sectors play a dominant role in most countries and contribute the most to GDP. Agriculture plays a vital role in Syrian Arab Republic; while wholesale, retail trade and hospitality services contribute nearly 1/3 of GDP in Palestine.

TABLE 1. GROSS DOMESTIC PRODUCT (GDP) IN WEST ASIA (VALUE ADDED BY SECTOR IN 2019).

	VALUE ADDED BY ISIC SECTOR (IN %)							GDP PER CAPITA (USD)	% OF WEST ASIA GDP
	A-B	C-E	D	F	G-H	I	J-P		
QATAR	0.2	41.9	8.2	13.4	7.9	5.6	31.0	62088	9.3
UAE	0.7	37.7	8.7	8.4	14.5	8.8	29.8	42701	20.5
KUWAIT	0.4	48.8	6.2	2.5	4.5	5.4	38.4	32372	7.4
BAHRAIN	0.3	33.4	18.2	8.1	6.9	7.5	43.7	23443	1.9
KSA	2.2	41.9	12.5	5.5	10.0	6.1	34.3	23140	38.7
OMAN	2.3	45.5	10.0	6.1	7.8	5.6	32.8	15343	3.9
LEBANON	5.6	9.8	7.3	3.8	17.5	5.8	57.5	7812	2.4
IRAQ	3.3	47.8	2.0	4.0	7.7	9.8	27.4	5981	11.0
JORDAN	5.4	24.0	19.6	3.0	10.4	9.8	47.3	4405	2.0
PALESTINE	8.5	15.2	12.9	6.4	26.0	6.0	37.9	3439	0.7
SYRIAN ARAB REPUBLIC	20.6	26.8	4.7	3.4	22.5	9.5	17.3	1558	1.0
YEMEN	19.0	15.9	11.1	4.6	20.3	15.2	24.9	866	1.2

Source: United Nations National Accounts Statistics: Main aggregates and detailed tables. ISIC A-B: agriculture, hunting, forestry, fishing; ISIC C-E: mining, manufacturing, utilities; ISIC D: manufacturing; ISIC F: construction; ISIC G-H: wholesale, retail trade, restaurants and hotels; ISIC I: transport, storage and communication; ISIC J-P: other activities.

1.4 KEY FINDINGS

The report provides the background and baseline data on the regional environmental impacts of natural resource use. It also sets out potential outlooks for natural resource use and GHG emissions from 2015 to 2060 in the region. These findings are to be used in regional consultations to develop the regional vision for the sustainable use of resources and shape the relevant and targeted policies required.

FINDINGS FROM THE ENVIRONMENTAL IMPACT ANALYSIS

- The results demonstrate a very strong connection between economic growth and environmental impacts in West Asia (**Figure 1**). The production perspective (PBA) features weak absolute decoupling for biodiversity loss, weak relative decoupling for water stress and no decoupling for GHG emissions. When viewed from the consumption perspective (CBA), absolute decoupling for biodiversity disappears, for water stress there is a sign of very weak absolute decoupling, and for GHG emissions there is no decoupling.
- Average per capita GHG emissions in 2019 amounted to 12.1 tCO_2eq (PBA) and 10.6 tCO_2eq (CBA) (**Figure 2a**). In both cases, GHG emissions were significantly above the global average (6.4 tCO_2eq per capita/year) and similar to the GHG emissions observed in China and the European Union.
- Nearly 90 per cent of land use-related biodiversity loss is embodied in imported products (**Figure 6a**). Addressing this requires supply chain management action to ensure best practice in producer regions and potentially changing the origins of imports to reduce the biodiversity impacts of consumption.
- West Asia suffers from high water stress due to its climate and topography (**Figure 8a**). Water stress impacts in the West Asia region have remained mostly unchanged since 1996. Water stress can be reduced by improving water productivity, reducing production and can potentially be reduced through trade adjustments, in particular by reducing exports (Weinzettel and Pfister 2019), and potentially adjusting imports. Regions with surplus water could relieve water stress in arid regions by selling water-intensive food products.
- Increasing population and affluence were the key forces driving environmental impacts. At the same time, environmental degradation and climate change continue to impact population groups in very different ways.
- Technological change has also had a growing effect on GHG emissions (**Figure 4**). In West Asia, the greenhouse gas emission level highly dependent on fossil fuel-based energy systems and is at a stage of economic development which relies heavily on energy-intensive sectors (e.g. steel, cement).

FINDINGS FROM THE ANALYSIS OF FUTURE SCENARIOS

- The baseline Historical Trends scenario projects a massive increase in total material extraction in West Asia, especially in Saudi Arabia, to support economic and population growth (**Figure 21**). In this scenario, Saudi Arabia maintains the largest share of material extraction in the region with more than 50 per cent from 2015 to 2060.
- Biomass, metal ores and fossil fuels in West Asia retain the same production/extraction rates throughout 2015 to 2060. Conversely, the extraction of non-metallic minerals grew substantially from 2015 to 2060, increasing their share from 46 per cent in 2015 to 74 per cent of total material extractions in 2060 under the Historical Trends scenario.
- Per capita material extractions in most countries in West Asia reach their peaks by 2040 but only decrease slightly afterwards under the Historical Trends scenario.
- This scale of growth in resource use – without improvements to manage the impacts of extraction, use and disposal of materials and resources – would result in substantial stress on resource supply systems and waste management systems, and unprecedented levels of environmental pressures and impacts.
- GHG emissions in the West Asia region are significantly above the global average and in the Historical Trends scenario are set to increase from 1.6 billion tCO_2eq in 2015 to 5 billion tCO_2eq in 2060.
- Resource efficiency (RE), sustainable consumption and production (SCP), and climate mitigation policies complement each other. RE and SCP policies significantly reduce all categories of material extraction and improve resource use productivity in West Asia, thus fostering economic growth in the region relative to Historical Trends. However, they are not necessarily efficient or effective in reducing emissions. As for climate mitigation policies, these would help West Asia cut massive emission levels, but would also slightly downgrade their economy.
- The Towards Sustainability scenario combines all these policies and would provide a win-win

solution for the countries of West Asia; pressure on the environment and material extraction is reduced without sacrificing economic growth. A more equal distribution of income and efficient resource use would also be likely.

- Towards Sustainability policies would, in particular, support Jordan, Oman and Saudi Arabia in reducing their material extraction rates by more than 46 per cent relative to Historical Trends by 2060, contributing significantly to relieving pressure on the regional and global environment.
- Non-metallic minerals and gas extraction, especially crude oil and metal ore extraction in West Asia, would be reduced materially with the implementation of Towards Sustainability policies compared with Historical Trends. Major reductions have been observed in Saudi Arabia and the UAE, although material extraction reductions have been experienced in all countries in West Asia.
- A key component in the Towards Sustainability policies supporting economic growth in West Asia is to improve resource use productivity.
- Well-being indicators grow faster than resource extraction with improved resource productivity and the relative decoupling of well-being from resource use.

2 ENVIRONMENTAL IMPACTS IN WEST ASIA

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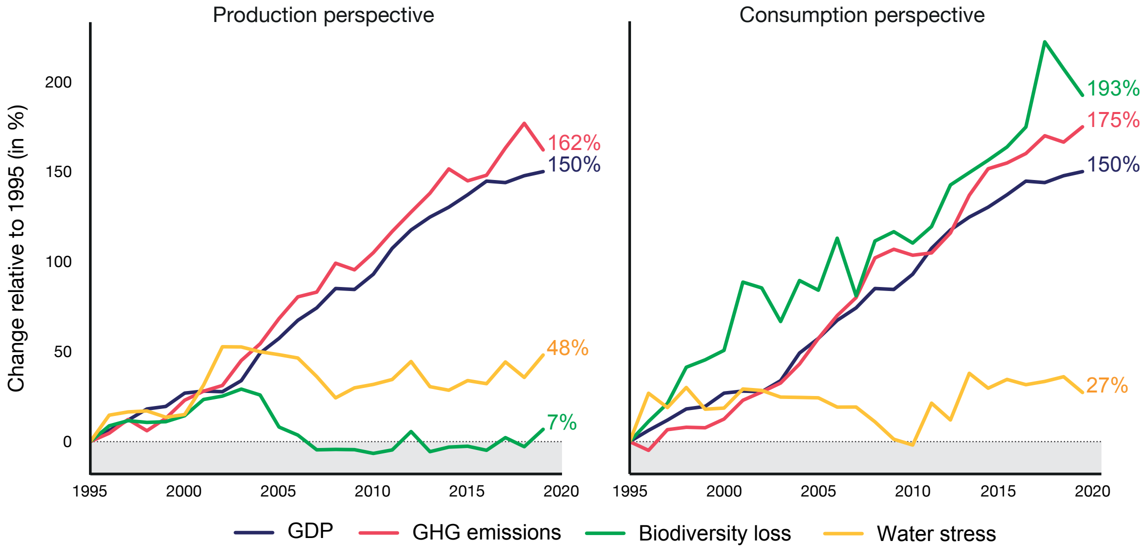
2.1 STATUS AND TRENDS

This section provides an overview of the GHG emissions, biodiversity loss and water stress in West Asia. The results are presented from two perspectives: a production perspective (PBA) and a consumption perspective (CBA). PBA looks at the environmental impacts in a specific country following the extraction and use of natural resources within its borders. CBA considers the impacts of the extraction and use of the natural resources in other countries to meet the demand in a specific region, and is the concept underlying footprint studies, such as carbon footprints.

The PBA method is the primary method used by statistical offices as well as international organizations. However, international fragmentation and the globalization of production processes has raised awareness of the need to complement the PBA approach with other accounting approaches. The CBA has emerged as one of the most suitable options. Both methods have their strengths and weaknesses, and the suitability of each method depends on the issue at hand. The PBA method does not account for carbon leakage, a phenomenon whereby countries reduce their domestic emissions by shifting production abroad. For instance, a country may reduce production at home and import a product from abroad. In this case, global emissions might increase if production has shifted to another country with higher GHG emissions, but the home country is rewarded because its PBA decreases. On the other hand, the CBA method fails to credit countries for cleaning up their export industries (Kander *et al.* 2015). For instance, a country may improve its production for exports by introducing renewable energy into its electricity mix. In this case, global emissions would decrease because exported goods are produced with cleaner energy, but the country is not rewarded because its CBA does not decrease.

Figure 1 demonstrates the decoupling relationship between environmental impacts (GHG emissions, biodiversity loss and water stress) and economic growth in West Asia. From a production perspective (PBA), weak absolute decoupling is found for biodiversity loss, weak relative decoupling for water stress and no decoupling for GHG emissions. When viewed from a consumption perspective (CBA), absolute decoupling for biodiversity disappears and changes into no decoupling (biodiversity loss increased by 143 per cent compared with 136 per cent growth in GDP since 1995). For water stress, there is a sign of very weak absolute decoupling, and for GHG emissions there is no decoupling (GHG emissions increased by 197 per cent since 1996). In general, these results are worrisome, especially for GHG emission and biodiversity loss from a CBA perspective, and they demonstrate a very tight connection with economic growth in West Asia. It is worth noting that these results are not common, since countries/regions at a similar level of economic development (e.g. China, India) tend to demonstrate evidence of relative decoupling.

FIGURE 1. ENVIRONMENTAL IMPACTS VERSUS ECONOMIC GROWTH IN THE WEST ASIA REGION, 1995–2019



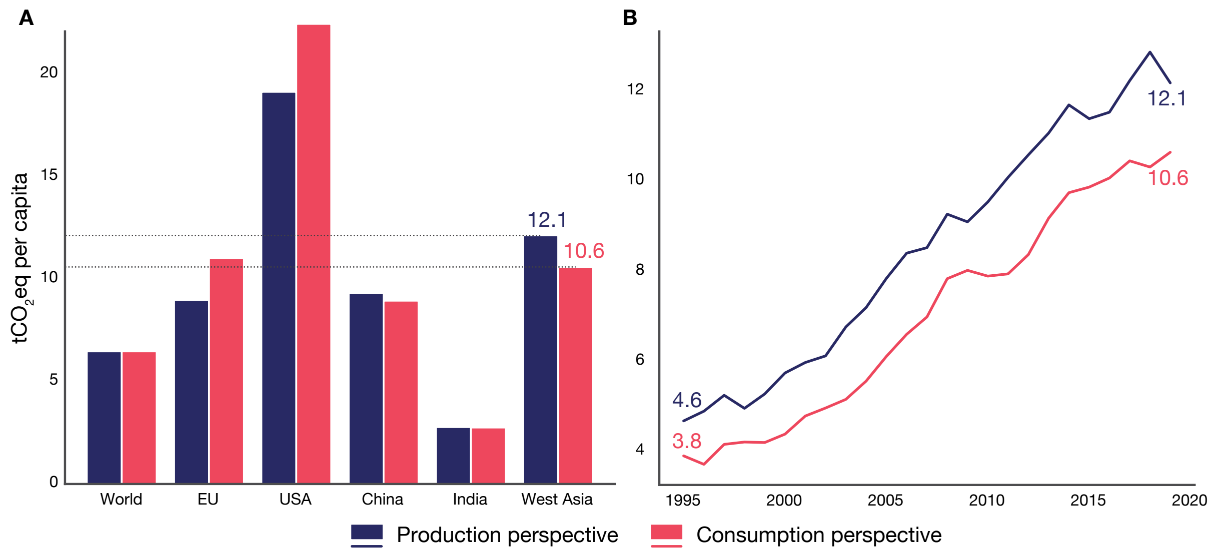
Source: Elaborated by the author using EXIOBASE v3.8.2, GDP from United Nations National Accounts Statistics: Main Aggregates and Detailed Tables. Biodiversity loss is measured as PDF (Potentially Disappeared Fraction of species) and only accounts for land use-related biodiversity loss.

2.1.1 GHG EMISSIONS

In the West Asia region, GHG emissions in 2019 amounted to 12.1 tCO_2eq per capita from a production perspective and 10.6 tCO_2eq per capita from a consumption perspective (**Figure 2a**). In both cases, GHG emissions are considerably above the global average (6.5 tCO_2eq per capita/year) and similar to GHG emissions in China and the European Union.

Between 1995 and 2019, GHG emissions increased considerably (almost by a factor of three) in the West Asia region. The increase follows an upward trend without stabilization in recent years, which partially reflects economic development in the region.

FIGURE 2. (A) GHG EMISSIONS PER CAPITA IN WEST ASIA AND SELECTED COUNTRIES/ REGIONS (2019); **(B)** GHG EMISSIONS PER CAPITA IN WEST ASIA (1995–2019)



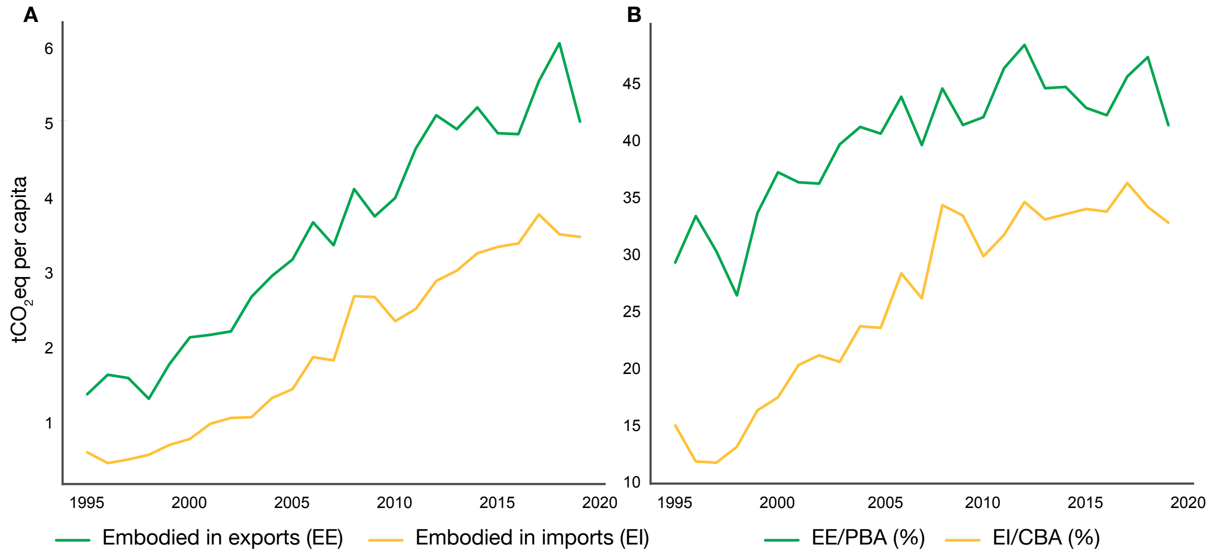
Source: Elaborated by the author using EXIOBASE v3.8.2

The production of traded goods generates a considerable amount of GHG emissions in West Asia. GHG emissions embodied in trade have increased over time, with emissions embodied in exports experiencing a higher increase than in imports. The upward trend has continued since 1995 (**Figure 3**).

It is worth noting that the difference between PBA and CBA emissions is usually attributed to three factors (see e.g. Jakob and Marschinski, 2012): differences in the trade balance between countries (if a country exports more than it imports, PBA will be higher than CBA, all things being equal); specialization (if a country exports a basket of goods that is on average more emissions-intensive than its basket of imports, PBA will be higher than CBA, all things being equal) and different emissions intensities (if an exporting country emits more GHG emissions to produce the same product as the country producing imported goods, PBA will be higher than CBA, all things being equal).

In 2019, emissions embodied in exports accounted for 41 per cent of production-based emissions, while emissions embodied in imports were 33 per cent of consumption-based emissions. In absolute terms, this means embedded GHG emissions in exports of 5.0 $tCO_{2e}q$ and in imports of 3.5 tCO_2eq per capita/year. Trade shares of both CBA and PBA increased mainly up to 2010 and have since stabilized (**Figure 3b**). Note that in absolute terms (**Figure 3a**) trade-related emissions are still rising but they are increasing by the same amount as domestic emissions (i.e. emissions which occur in West Asia to meet consumption in the region).

FIGURE 3. (A) GHG EMISSIONS EMBODIED IN TRADE (1995–2019); **(B)** EMISSIONS EMBODIED IN TRADE AS A PERCENTAGE OF TOTAL EMISSIONS (1995–2019)



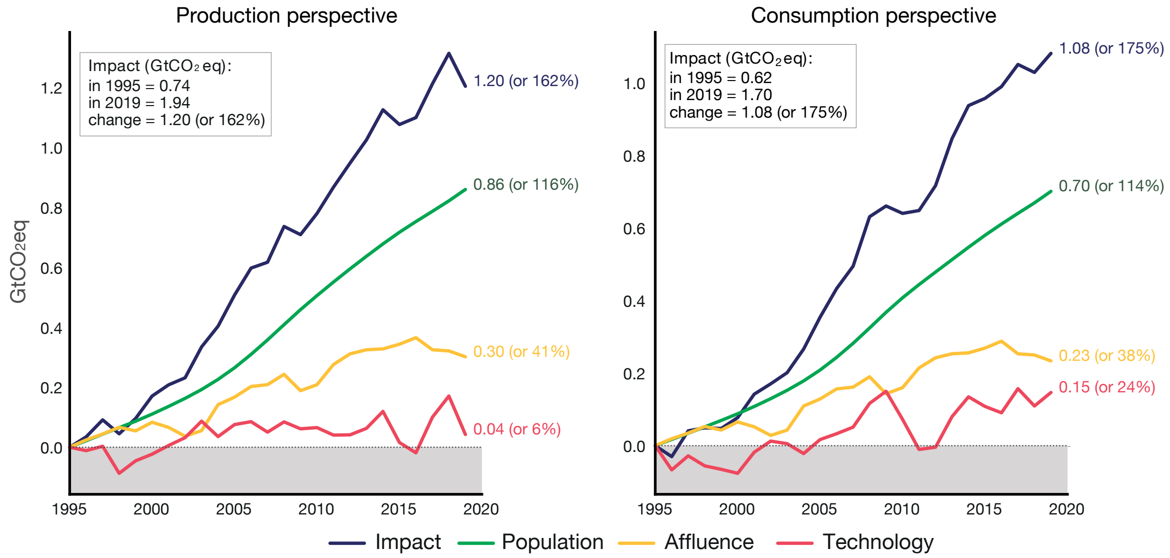
Source: Elaborated by the author using EXIOBASE v3.8.1. Note EE – impacts embodied in exports, EI – impacts embodied in imports

The high average rate of per capita GHG emissions in West Asia can have different drivers. Often these include changes in population, increasing affluence, as well as a lack of technological changes which usually keep emissions down. Typically, environmental pollution tends to rise in the early stages of economic development due to large capital investments (e.g. roads, bridges, houses, machinery). During this phase, GHG emissions tend to increase faster than GDP, this pattern is evident in Figure 1 (similar patterns have been observed in the USA and Western Europe roughly between 1880 and 1920). In the latter stages, improvements in technology, as well as decreasing investments in capital (capital stocks accumulate and can be used for productive processes for years or decades, see e.g. Ye *et al.* 2021), allow economies to produce more with less pollution (i.e. relative decoupling). Such patterns are currently observed in China, for instance, while high-income countries/regions (e.g. EU, USA) demonstrate evidence of absolute decoupling (UNEP 2020). Given the average income level in the West Asia region (note that West Asian countries differ significantly in terms of GDP), which is similar to that of China and about four times higher than that of India, one would expect to observe relative decoupling, however that has not been the case. This could be due to relatively cheap fossil fuel energy in many countries in the West Asia region which could hinder the transition towards non-fossil fuel energy sources. Also, war and conflicts in the region, which destroy accumulated capital stocks, play an important role. Globally, the decreasing costs of renewables, and solar power in particular, are likely to speed up the renewable energy transition in the West Asia region, home to some of the cheapest utility-scale solar PV on earth. In fact, the Kingdom of Saudi Arabia 600 MW Al Shuaiba PV IP project set a new world record for the lowest price bid of US$ 0.0104/kWh in 2021.

To support our analysis and understand the main driving forces, an impact-population-affluence-technology (IPAT) decomposition analysis was performed for each environmental indicator. IPAT equates impact (I) on the environment as a function of three factors: population (P), affluence (A) and technology (T). T also includes changes in the structure of the economies, such as a shift to service sectors. This analysis is a common method applied in environmental literature that expresses a specific environmental impact (e.g. GHG emissions) as a function of population, affluence (GDP per capita) and technology (impact/GDP).

The IPAT decomposition results for GHG emissions presented in Figure 4 show that GHG emissions (production perspective) in West Asia increased by 1.20 $GtCO_2eq$ (or 162 per cent) from 0.74 $GtCO_2eq$ in 1995 to 1.94 $GtCO_2eq$ in 2019. The key driving factor for this increase was change in the population (0.86 $GtCO_2eq$), followed by affluence (0.30 $GtCO_2eq$) and technology (0.27 $GtCO_2eq$). If the population had increased as it did, while everything else had remained constant (i.e. *ceteris paribus*), GHG emissions in West Asia would have increased by 0.86 $GtCO_2eq$ compared with the 1995 level. The results and importance of different drivers are very similar when viewed from a consumption perspective (**Figure 4**).

FIGURE 4. IPAT DECOMPOSITION FOR GHG EMISSIONS, 1995–2019



Source: Elaborated by the author using EXIOBASE v3.8.2 and GDP from United Nations National Accounts Statistics: Main Aggregates and Detailed Tables

Another aspect worth highlighting is that technological change (expressed as GHG emissions per unit of GDP) had a growing effect in both cases (production and consumption). Typically, in the early stages of economic development, energy use and associated GHG emissions tend to grow faster than GDP because countries build infrastructure (roads, bridges, houses) and heavy industry (Reddy and Goldemberg, 1990). As economies mature, they tend to use energy and resources more efficiently, which leads to the economy's declining carbon intensity (GHG per unit of GDP decline). Thus, it is likely that the observed increasing effect of technological change in West Asia is because the region is going through a phase in its economic development that requires large investments in infrastructure (roads, bridges, etc.) which are heavily dependent on inputs from energy-intensive, fossil fuel-dependent industries (e.g. steel, cement).

2.1.2 BIODIVERSITY LOSS

Land use causes various environmental impacts, such as the destruction of natural habitats. It is also the main driver of biodiversity loss, soil degradation and the loss of other ecosystem services. Land use-related biodiversity loss in the West Asia region is relatively low compared with other parts of the world as the endemic richness is comparatively low and in arid places is often limited by water availability (**Figure 5a**).

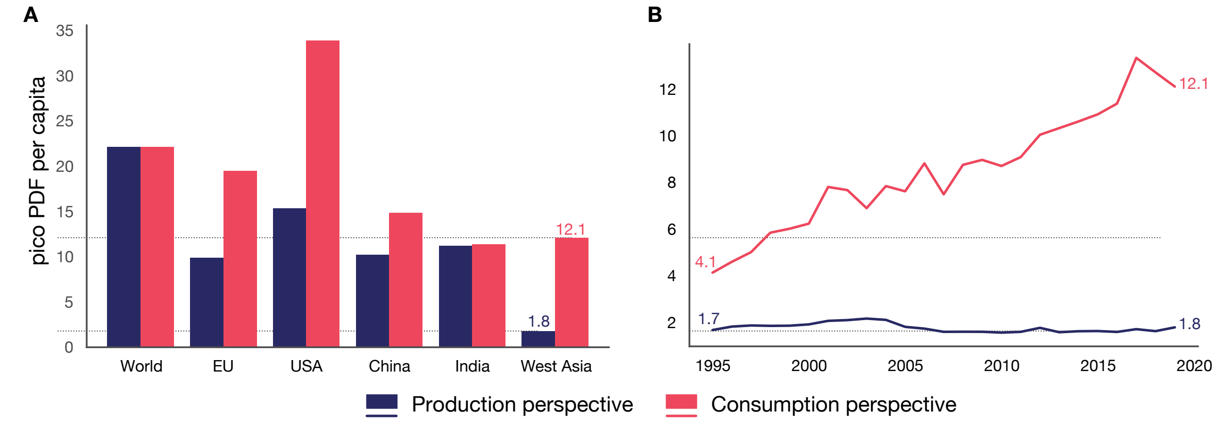
As a consequence, biodiversity impacts from a production perspective are considerably lower than in other regions. From a consumption perspective, the impacts are lower than the world average and similar to those in China and India.

Land use-related biodiversity loss from a consumption perspective has increased from 4.1 pico-PDF (potentially disappeared fraction of species) per capita in 1995 to 12.1 pico-PDF per capita in 2019 (**Figure 5b**). From a production perspective, biodiversity loss has remained virtually unchanged.

More than 90 per cent of consumption-based impacts are embodied in imported products, and thus CBA closely follows the pattern of biodiversity impacts embedded in imports (**Figure 6a**). Given that imports are causing the major share of biodiversity impacts and given high spatial variability in these biodiversity impacts, the changing origins of imports (i.e. the country from where the goods are imported) can have a significant influence on overall consumption-based impacts and can therefore explain some variability over time. It should be noted that the biodiversity indicator that is used accounts for the global endemic species richness extinction risk and thus lends great weight to the islands' and species' rich ecosystems.

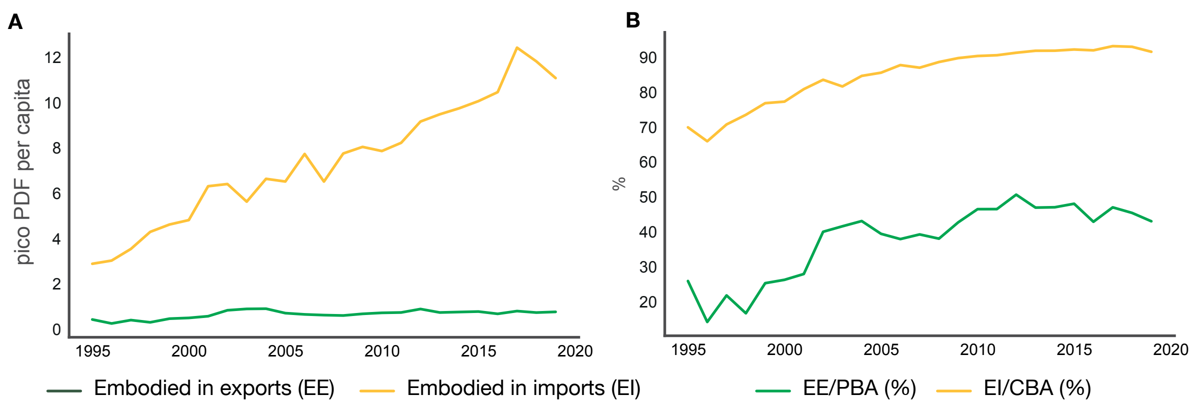
From 1995 to 2010, the share of biodiversity loss from imports increased in West Asia. Since 2010, this share has remained relatively stable (**Figure 6a**).

FIGURE 5. (A) BIODIVERSITY LOSS PER CAPITA IN WEST ASIA AND SELECTED COUNTRIES/REGIONS (2019); **(B)** BIODIVERSITY LOSS PER CAPITA IN WEST ASIA 1995–2019



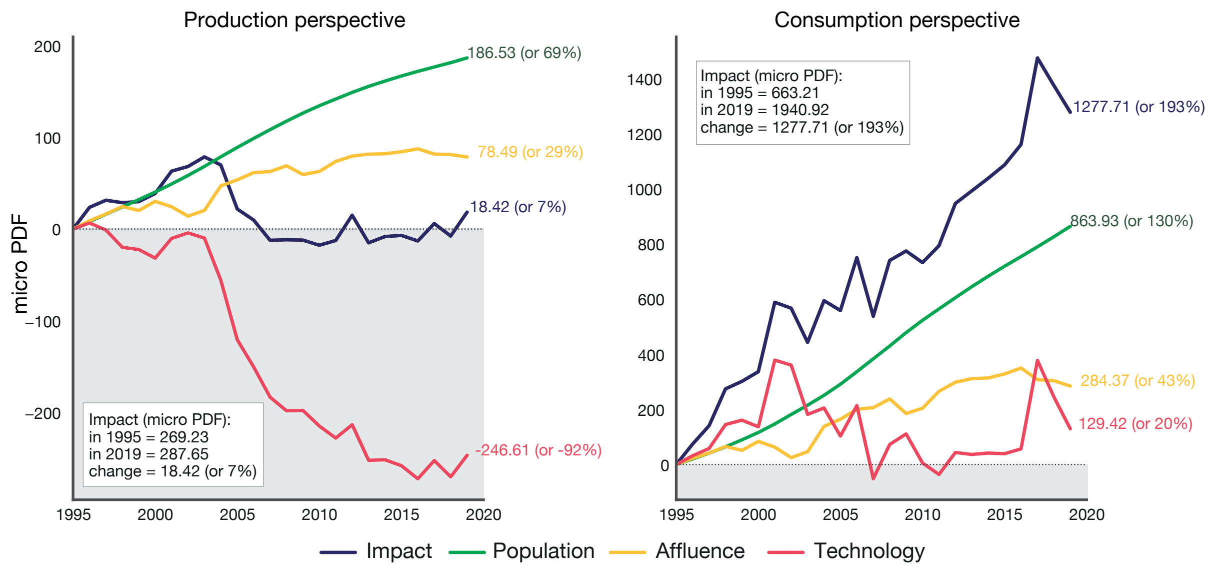
Source: Elaborated by the author using EXIOBASE v3.8.2

FIGURE 6. (A) BIODIVERSITY LOSS EMBODIED IN TRADE (1995–2019) **(B)** BIODIVERSITY LOSS EMBODIED IN TRADE AS A PERCENTAGE OF TOTAL BIODIVERSITY LOSS (1995–2019)



Source: Elaborated by the author using EXIOBASE v3.8.1

FIGURE 7. IPAT DECOMPOSITION FOR BIODIVERSITY LOSS, 1995–2019.



Source: Elaborated by the author using EXIOBASE v3.8.1 and GDP from United Nations National Accounts Statistics: Main Aggregates and Detailed Tables

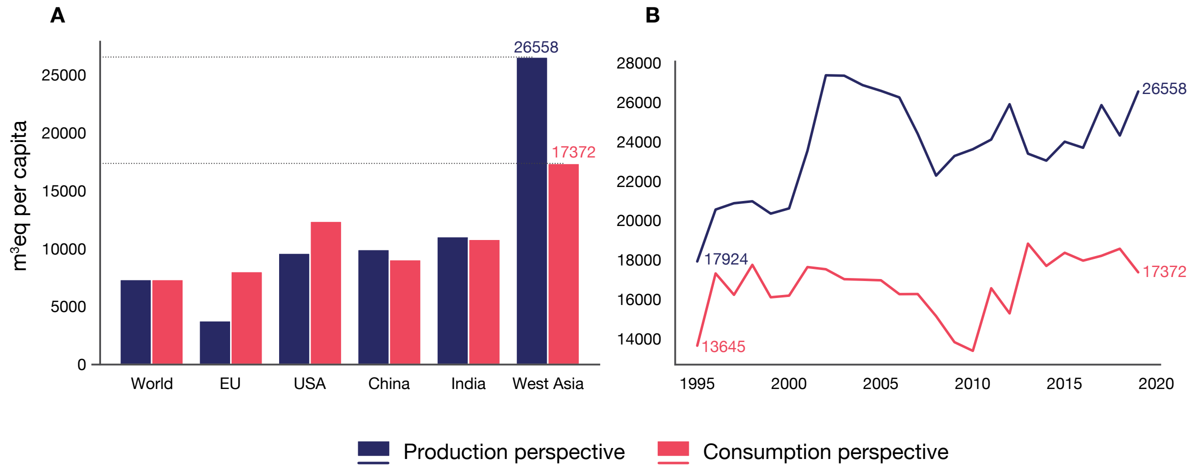
As shown in **Figure 7**, biodiversity loss in West Asia has increased by 18 micro-PDF (or 7 per cent): from 270 micro-PDF in 1995 to 287 micro-PDF in 2019. Improvements in technology (here expressed as biodiversity loss per unit of GDP) were responsible for a 247 micro-PDF decline in biodiversity loss, while changes in population (187 micro-PDF) and affluence (79 micro-PDF) increased biodiversity loss. From a consumption perspective, biodiversity loss increased by 1278 micro-PDF, from 663 micro-PDF in 1995 to 1941 micro-PDF in 2019. West Asia's increasing population (863 micro-PDF) was the key force driving biodiversity loss, followed by affluence (280 micro-PDF). Technological change (129 micro-PDF) also slightly increased biodiversity loss but its effect fluctuated over time.

2.1.3 WATER STRESS

Fresh water is a vital resource for humans and ecosystems. The majority of global water consumption comes from renewable sources (rain, soil moisture, rivers, lakes and groundwater). However, in some cases, water consumption may exceed water availability and lead to water stress. West Asia has some of the largest per capita water stress impacts in the world due to its climate and topography. In the region, water stress impacts related to production are higher than the impacts related to consumption (**Figure 8a**).

Over the past decades, water stress impacts in the West Asia region have shown considerable fluctuations (**Figure 8b**) and an increasing trend in both cases (production and consumption).

FIGURE 8. (A) WATER STRESS PER CAPITA IN WEST ASIA AND SELECTED COUNTRIES/ REGIONS (2019); **(B)** WATER STRESS PER CAPITA IN WEST ASIA 1995–2019



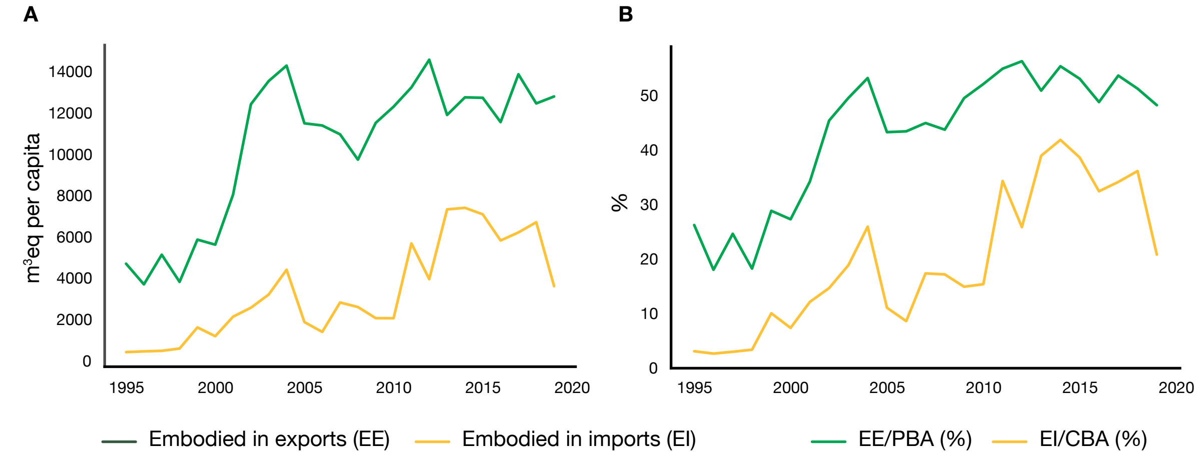
Source: Elaborated by the author using EXIOBASE v3.8.2

The fluctuations in water stress impacts embodied in exports and imports reflect varying production and export amounts, as well as different impacts of water consumption, depending on spatial considerations (as discussed for biodiversity loss above) and temporal variation **(Figure 9a)**.

In the West Asia region, water scarcity impacts are higher from a production perspective than from a consumption perspective. This implies that the region is a net exporter of scarce water to other regions and happens because food production requires irrigation. West Asia is a relatively water-scarce region, thus irrigation compounds water scarcity issues. Given that some food items are exported, it also means that part of the water scarcity issues are also "exported" because they are embodied in exports. From a consumption perspective, the impacts are lower. This is most likely because imports come from regions where water is more abundant and doesn't lead to equally severe water scarcity issues. In addition, water stress impacts embodied in imports and exports increased during the period from 1956 to 2019 (**Figure 9b**), reflecting the general trend towards greater international trade. Increased efficiency in biomass extraction (yields) and supply can help reduce water stress impacts. Water stress impacts can also potentially be reduced through trade adjustments. Regions with surplus water could deliver water to arid regions by trading water-intensive food products. This was identified as an important measure for the Middle East in the first virtual water assessment (Allan 1998).

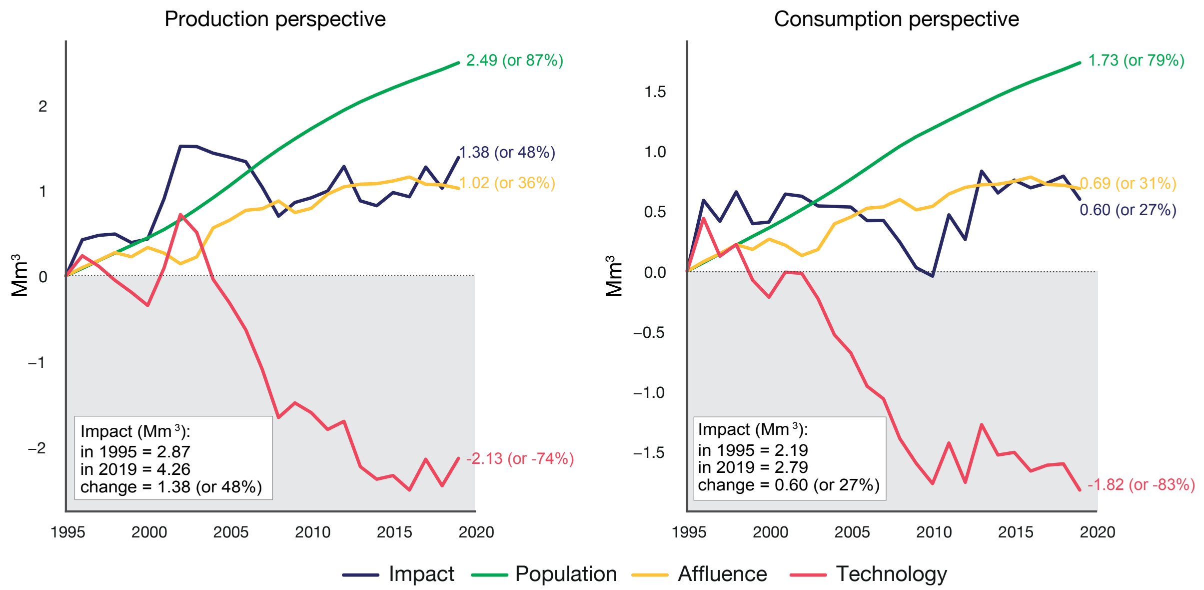
In West Asia, exports are a major driver of water stress impacts. In 2019, water stress impacts from embodied exports accounted for roughly 50 per cent of total production-based impacts (**Figure 9b**).

FIGURE 9. (A) WATER STRESS EMBODIED IN TRADE (1995–2019); **(B)** WATER STRESS EMBODIED IN TRADE AS A PERCENTAGE OF TOTAL WATER STRESS (1995–2019)



Source: Elaborated by the author using EXIOBASE v3.8.2

FIGURE 10. IPAT DECOMPOSITION OF WATER STRESS, 1995–2019



Source: Elaborated by the author using EXIOBASE v3.8.2 and GDP from United Nations National Accounts Statistics: Main Aggregates and Detailed Tables

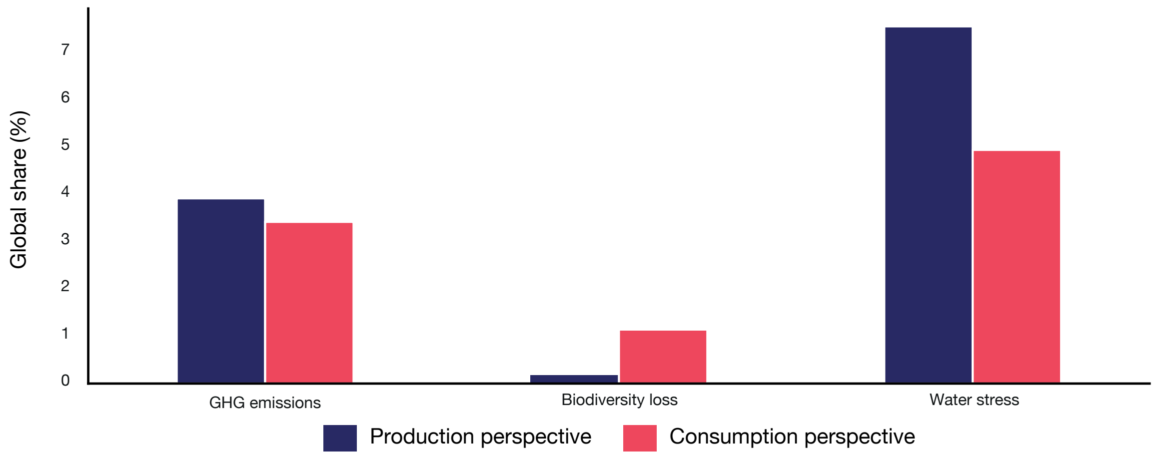
Water stress (from a production perspective) has increased by 1.38 Mm^3 (or 36 per cent) from 2.87 Mm^3 in 1995 to 4.26 Mm^3 in 2019 (**Figure 10**). A rising population (2.49 Mm^3) and affluence (1.02 Mm^3) were the major contributors to the increase in water stress. If everything else had remained constant, water stress in the West Asia region would have increased by 3.51 Mm^3 compared with the 1995 level. However, changes in technology (here expressed as water stress per unit of GDP) accounted for a -2.13 Mm^3 reduction in water stress and were an important factor in tackling water stress.

On the consumption side, water stress has increased by 0.6 Mm^3 from 2.19 Mm^3 in 1995 to 2.79 Mm^3 in 2019. The factors responsible for this change are very similar to those observed in the production case.

2.1.4 WEST ASIA IN A GLOBAL CONTEXT

West Asia generally experiences above average climate and water stress impacts. Water impacts can be attributed to large-scale domestic irrigation due to the climate and intensive agricultural activities in some countries in the region (FAO 2022; Allan 1998). On the other hand, the land use-related biodiversity impacts are below the global average. Globally, the region accounts for about 3–4 per cent of GHG emissions, 0–1 per cent of biodiversity loss and 5–7 per cent of water stress (**see Figure 11**) with a 2 per cent population share. This is mainly due to the spatial variability of the water and land-use impacts of biomass production, which depend on the climate and ecoregion conditions, in addition to production efficiency and consumption. For GHG emissions, the large fossil fuel sector plays a major role.

FIGURE 11. WEST ASIA'S GLOBAL SHARE OF IMPACTS (2019)



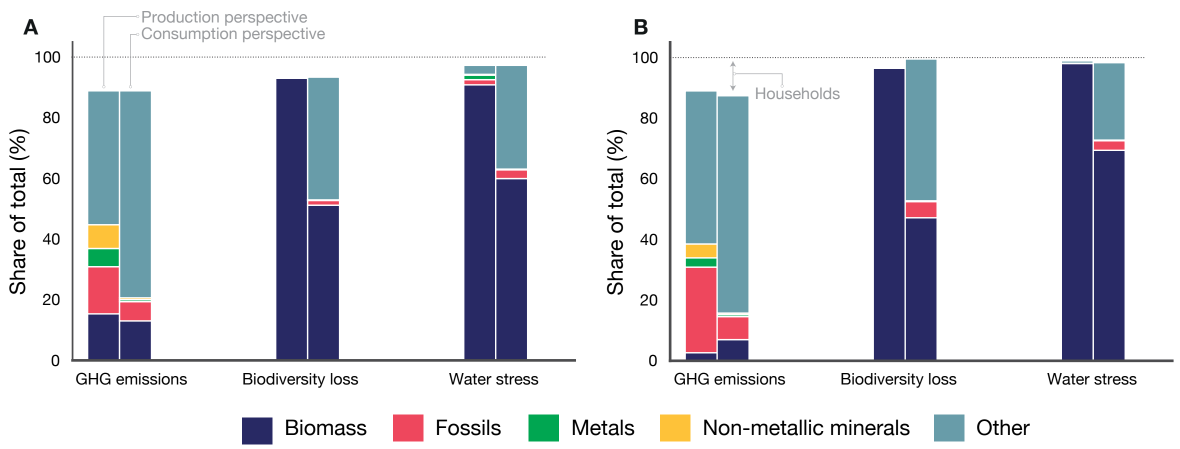
Source: Elaborated by the author using EXIOBASE v3.8.2

2.2 ENVIRONMENTAL IMPACTS BY RESOURCE GROUP

In West Asia, biomass production is the main driver of land use-related biodiversity loss and water stress. Fossil fuel resources (e.g. those which are needed to produce electricity) account for the largest share of GHG emissions (**see Figure 12**). Compared with the global average, there is a higher share of fossil fuels in GHG emissions and water stress for both PBA and CBA and a higher share of biodiversity loss due to fossil fuels in the CBA.

From a production perspective, more impacts are caused by material production (biomass, fossil fuels, metals, non-metallic minerals), while from a consumption perspective, a higher share is caused by other (i.e. upstream) sectors such as electricity. This is common, since final demand is usually satisfied by downstream sectors, such as the electronics or service sectors. Evidently, however, the hydrocarbon production sector has a very high share in West Asia compared with global levels. Sectors distinct from resource production are summarized as "Other" and refer to e.g. transport and heat or electricity generation and thus account for a major share of GHG emissions.

FIGURE 12. IMPACTS BY RESOURCE GROUP. GLOBAL **(A)** AND WEST ASIA **(B)** (2019)



Source: Elaborated by the author using EXIOBASE v3.8.2. The consumption perspective shows the impact by final product (e.g. a car bought in the West Asia region will include impacts from metal extraction and processing, as well as impacts from transportation, manufacturing, etc.), while the production perspective shows the contribution of sectors causing the impact (e.g. GHG emissions due to different fuel use within a car manufacturing site). The bars represent impacts by industry. The difference between the 100 per cent line and the bars are related to impacts caused by households (e.g. fuel for private cars). "Other" refers to non-material sectors (such as transport, health, education, public administration and other services).

2.2.1 METAL RESOURCES

Metals underpin the technologies and services that are essential in modern society. From infrastructure, industrial equipment and transport to information technology, virtually all activities and products rely on metals, at least indirectly. However, the extraction and processing of metals from mined ores has a range of environmental impacts. In 2019, global metal production was responsible for 6 per cent of total GHG emissions and for 1.5 per cent of water stress impacts (**Figure 12a**). In that same year, in West Asia, metals accounted for 4 per cent of the total GHG emissions but made no major contribution to total biodiversity loss and water stress **(Figure 12b**) because most biodiversity loss is caused by land use. Thus, even though metal extraction has some impact, it is relatively small as compared with the impact caused by agriculture and forestry which uses considerably more land than metal extraction.

2.2.2 NON-METALLIC MINERALS

Environmental impacts from non-metallic minerals (e.g. limestone, gravel, gypsum, dolomite, phosphate, salt) remain relatively low, both at the global level (7 per cent of GHG emissions) and the regional level (3 per cent of GHG emissions; see **Figure 12b**). The majority of impacts caused by non-metallic minerals come from the processing stage, particularly from the production of cement and fertilizers. These non-metallic minerals are typically used in the construction sector. Overall, non-metallic minerals in the West Asia region contribute relatively little to its environmental impacts. Nevertheless, mining activities may have local impacts on ecosystems through water and land use. Sand is a particular example as it is mined in large amounts from rivers and marine sources, causing damage to local ecosystems. Open pit mines are also transforming large areas and will potentially lead to future heavy metal emissions over the long term. Using land-based sand mines not mined from living riverbeds, or mining rock and crushing it to gravel and sand are viable options for many countries. The additional energy demand involved in crushing stone is small in comparison to the total impact of non-metallic minerals.

2.2.3 BIOMASS

Biomass resources are used for food, material feedstock and energy. Food is the most essential biomass extracted as it is vital for humans. However, food production is responsible for the majority of biodiversity loss, soil erosion and a large share of anthropogenic greenhouse gas emissions.

Food is mainly provided in the form of crops, animal products and other forms of biomass, such as insects or insect products, or mushrooms and algae. Non-food biomass, such as wood, can serve as feedstock for materials, used in construction, furniture production, paper mills, packaging and various chemical applications, and energy (in the residential and industrial sectors).

From a production perspective, biomass extraction and processing account for 14 per cent of global GHG emissions and just 2 per cent of GHG emissions in the West Asia region, and is the principal cause of biodiversity loss and water scarcity (see **Figures 12a** and **12b** above).

2.2.4 FOSSIL FUELS

The extraction, processing, distribution and use of fossil fuel resources are key drivers of GHG emissions in West Asia. Typically, the extraction and processing of oil and gas causes the largest share of GHG emissions. These impacts come from venting, flaring and final use, as well as leaks and other sources of fugitive emissions.

West Asia is one of the world's leading oil and natural gas producers. While fossil fuel resources account for 17 per cent of global GHG emissions, they cause 36 per cent of GHG emissions from a production perspective in West Asia, as shown in Figure 12b (2019 data). The refining of crude oil into products such as chemicals and fuels has the highest carbon footprint, primarily due to the significant heat demands of this process. Section 3.7 provides a more detailed overview of GHG emissions associated with fossil fuel resources.

For a better understanding of where these impacts occur and where potential intervention to reduce GHG emissions could take place, the flow of impacts was mapped through the West Asia fossil fuel industry's entire supply chain (**Figure 13**). This shows the source of impacts by sector and country (on the left), the intermediate demand by country and sector (in the middle), and the sector and country delivering to end users in different countries/regions (on the right). Each vertical slice in the figure has the same total emissions and attributes GHG emissions to a different player in the supply chain. In other words, the left side shows where the impacts originate (i.e. the producers who cause the impact), while the right side shows the consumers who purchased the goods and services.

The largest share (92 per cent) of fossil fuel GHG emissions occur directly in the West Asia region. The remaining 8 per cent occur indirectly, however most indirect emissions still occur in the fossil fuel sector but this happens outside the West Asia region.

Roughly 10 per cent of total impact (direct + indirect) is embodied in fossil fuel products (e.g. petrol for cars) sold directly to final consumers either in the West Asia region or abroad. The remaining 90 per cent of impact is embodied in products which are sold as intermediate inputs to other industries in the West Asia region or abroad. The largest share of impacts is embodied in intermediate goods exported to China (24 per cent), followed by India (12 per cent), the EU (9 per cent) and USA (6 per cent). Only 3 per cent of embodied impacts are associated with intermediate goods which remain in the West Asia region (e.g. impacts embodied in fossil fuels used by the manufacturing sector or public transport in the West Asia region). It is noted that 82 per cent of GHG emissions are embodied in the intermediate products which are sold to industries abroad which produce fossil fuels and related products. This may include the sale of crude oil which is then refined (abroad) into products such as chemicals and fuels.

Intermediate products can be sold as inputs into further production processes (e.g. plastic to produce car parts) or as an end product (e.g. a plastic bag sold in a grocery store). The use of intermediate products can continue through multiple stages. For instance, oil inputs can be used as feedstock to produce plastic, which is then used to manufacture car parts, in turn used in the car manufacturing process; this manufactured car is then sold to a logistics company that uses it to deliver goods either for business (this would be considered a further intermediate step) or to private customers (final demand).

To keep **Figure 13** as simple as possible, only the first intermediate stage and the final demand stage (e.g. a car sold for private use) are shown, this is the reason why there is a gap in the flow diagram. The first intermediate stage shows the impacts embodied in products sold by West Asia's fossil fuel industry and the final demand stage shows what kind of products these embodied impacts end up in (e.g. a car, construction material). The final demand stage shows that most impacts are embodied in fossil fuel products (26 per cent, for example in fuels sold for private households abroad), followed by services (21 per cent), manufacturing goods (18 per cent) and construction (14 per cent). Interestingly, more than 90 per cent of total impact is embodied in goods and services that are consumed abroad. Only 8 per cent of total impact ends up embodied in goods and services that are consumed in West Asia.

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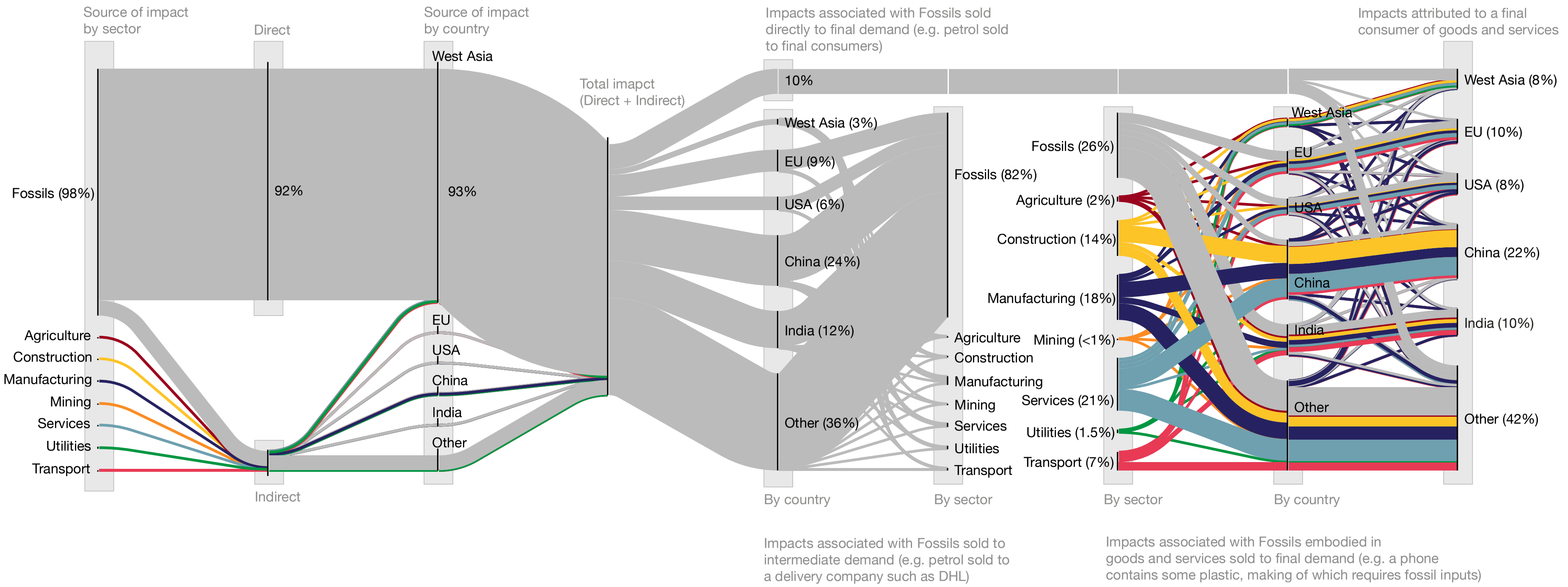
FIGURE 13. GLOBAL FLOW OF GHG EMISSIONS ASSOCIATED WITH FOSSIL FUEL RESOURCES (2019) WITH A FOCUS ON WEST ASIA. THE LEFT SIDE REPRESENTS THE SECTOR AND LOCATION OF TOTAL IMPACTS IN THE PRODUCTION, THE RIGHT SIDE SHOWS HOW THESE EMISSIONS ARE ALLOCATED TO DOWNSTREAM SECTORS, REGIONS AND FINAL CONSUMERS



Source: Elaborated by the author using EXIOBASE v3.8.2

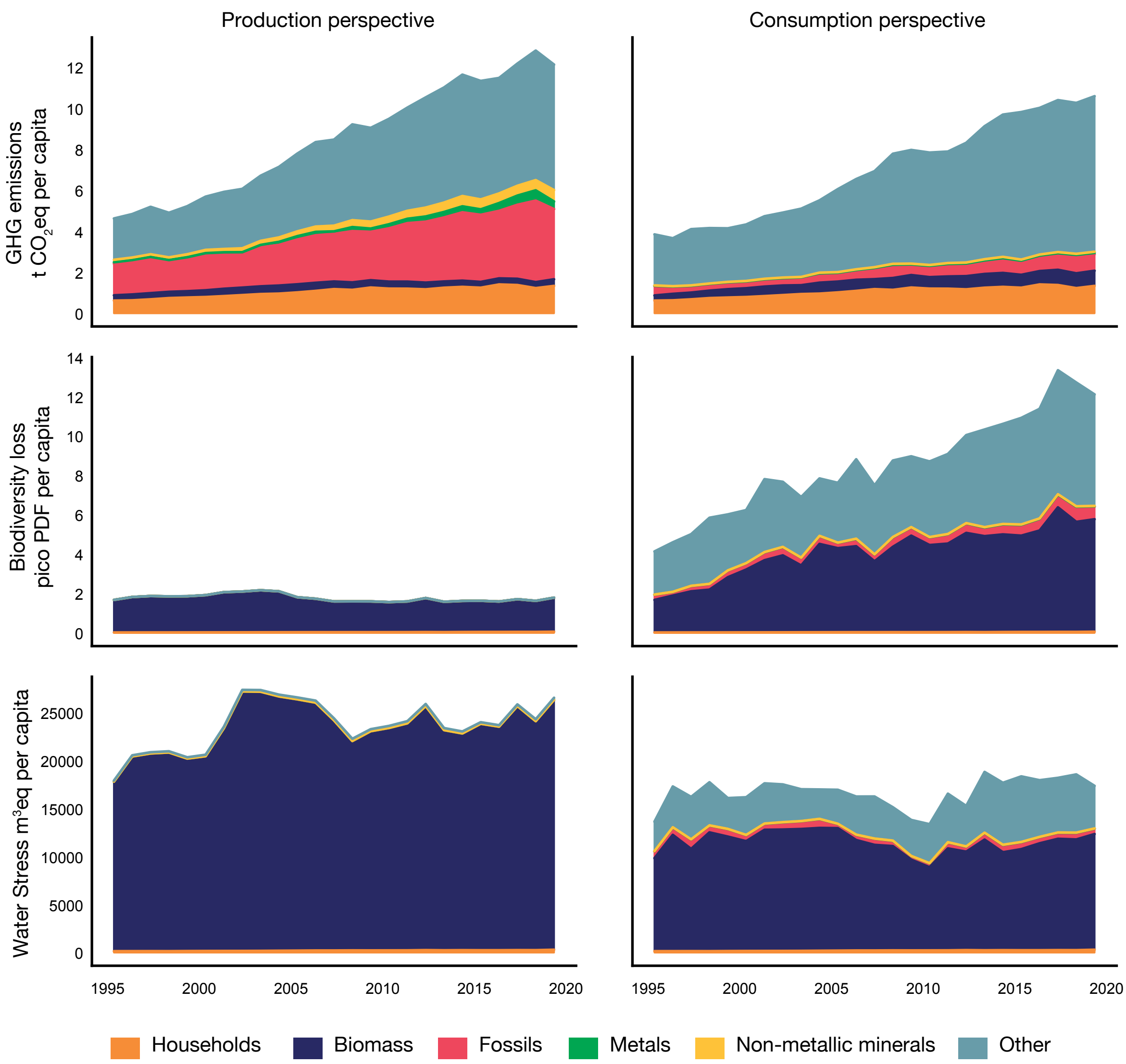
2.2.5 ENVIRONMENTAL IMPACTS BY RESOURCE GROUP OVER TIME

Figure 14 shows GHG emissions, biodiversity loss and water stress by resource group. In this figure, the direct impact by households is included to better illustrate the overall importance of different resource groups. Excluding households would miss some information about the importance of different resources. From 1995 to 2019, GHG emissions have increased steadily for nearly all resource groups from both perspectives (**Figure 14a**). As expected, fossil fuel resources (viewed from the production perspective) play an important role in the West Asia region, and their importance has increased over time. From the consumption perspective, the "Other" sector category (i.e. sectors other than resource extraction and processing) have also become more important over time.

Biomass resources that are used for food, material feedstock and energy are considered to be the major cause of land use-related biodiversity loss. The impact attributable to the use of biomass resources has declined slightly since 1995 when viewed from a production perspective, but increased when viewed from the consumption side (**Figure 14b**).

For water (**Figure 14c**), the relative importance of different resource groups has remained somewhat unchanged for both production and consumption perspectives over the period 1995–2019, and the fluctuations are stronger than the trend (mainly due to biomass-related fluctuations).

FIGURE 14. ENVIRONMENTAL IMPACTS BY RESOURCE GROUP (1995–2019)

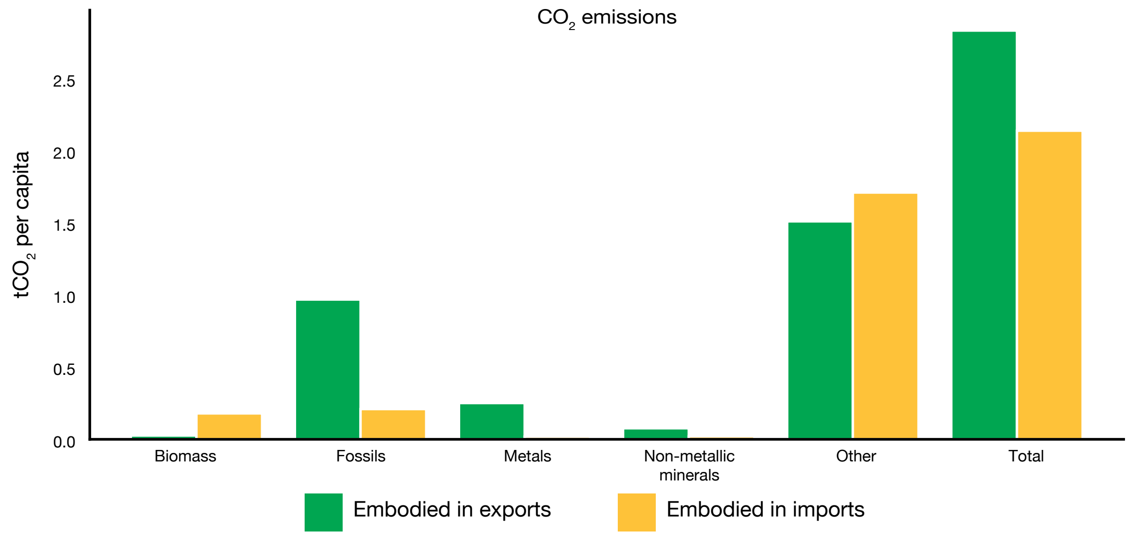


Source: Elaborated by the author using EXIOBASE v3.8.2. "Other" refers to non-material sectors (such as transport, electricity generation, education, public administration and other services)

2.2.6 ENVIRONMENTAL IMPACTS EMBODIED IN TRADE BY RESOURCE GROUP

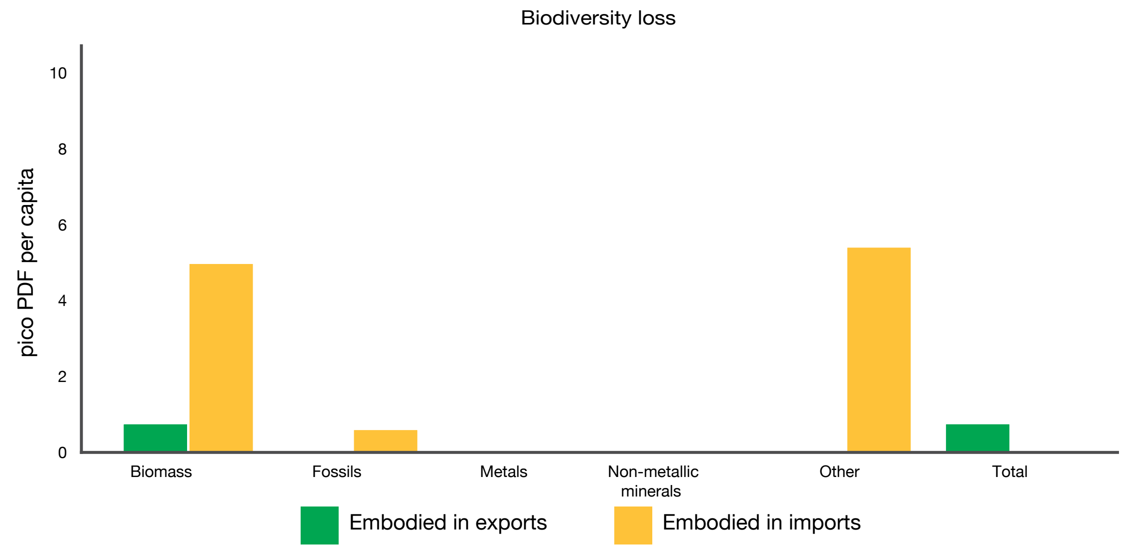
As evident from **Figure 15**, there are almost no GHG emissions embodied in imports of metals and non-metallic minerals. This is because the impacts are attributed to the product sold for final consumption, and metals and non-metallic minerals are not typical final consumption items; for example, it is uncommon to buy 1 tonne of steel in a hardware shop. Instead, consumers usually buy finished manufactured goods, such as a car, which contain some metals and embodied GHG emissions, or services (e.g. public transport) and these show up in the "Other" category in **Figure 15**. The highest share of impacts in imports is embodied in other products (predominantly comprised of services such as air travel) followed by biomass, which includes GHG emissions associated with the production of food. The largest share of emissions embodied in exports comes from the fossil fuel industry, followed by the "Other" category (services, public administration, etc).

FIGURE 15. GHG EMISSIONS EMBODIED IN TRADE BY RESOURCE GROUP, 2019



Source: Elaborated by the author using EXIOBASE v3.8.2

FIGURE 16. BIODIVERSITY LOSS IMPACTS EMBODIED IN TRADE BY RESOURCE GROUP, 2019



Source: Elaborated by the author using EXIOBASE v3.8.2

For biodiversity loss related to land use, the largest impact comes from biomass exports (e.g. food production) (**Figure 16**). On the import side, the largest share of impacts is embodied in the biomass and "Other" categories, followed by a small fraction of impacts embodied in the import of fossil fuels, which may be due to imports of fossil fuels from regions with relatively high biodiversity loss impact per unit of land use. Overall impacts embodied in imports are considerably greater than the impacts embodied in exports.

Nearly all water-related impacts embodied in exports come from biomass resources (**Figure 17**), which is not surprising as West Asia has among the largest water stress impacts in the world due to the dry climate across most of the region. Any export-linked biomass production is therefore likely to have considerable water stress impacts. Additionally, water use is dominated by agriculture globally and especially in drier climates.

FIGURE 17. WATER STRESS IMPACTS EMBODIED IN TRADE BY RESOURCE GROUP, 2019

Source: Elaborated by the author using EXIOBASE v3.8.2

3 RESOURCE USE IN WEST ASIA

This chapter discusses two potential outlooks for natural resource use and GHG emissions in West Asia from 2015 to 2060 based on model-based scenario projections and analysis. These two potential futures include a continuation of "Historical Trends", and a Towards Sustainability" pathway enabled by ambitious actions to promote resource efficiency and climate mitigation. The Historical Trends scenario analyses historical growth to provide projections for economic and population growth, material extraction, material productivity/efficiency improvements, regional material trade balance and total GHG emissions for the period 2015 to 2060. In the Historical Trends scenario, the key projections follow the Shared Socioeconomic Pathway 2 (SSP2) – the "middle of the road" narrative – as per O'Neill *et al.* (2017), where the world economy continues its historical trend of economic growth, population growth and urbanization rates. Material demand and resource efficiency are additional projections in the baseline Historical Trends. Detailed technical information, including these assumptions, is provided in the technical annex of this report.

The outlook for the Towards Sustainability pathway, in contrast to Historical Trends, includes two key policy packages – Resource Efficiency and Climate Mitigation. It follows previous assumptions in the report *Global Resource Outlook 2019: Natural Resources for the Future We Want* (IRP 2019a). Throughout the chapter, estimated results from imposing both policy packages are compared with the baseline Historical Trends scenario. Additionally, the results in the Towards Sustainability scenario, which combines these two policy packages so as to examine their interaction and aggregate impacts, are outlined.

The Resource Efficiency policy package/scenario aims to reduce resource extraction and use in regions by introducing (i) resource efficiency innovation strategies, (ii) volume resource extraction taxes to encourage more efficient resource use, and (iii) policies that reduce demand for resources. The Climate Mitigation package/scenario includes measures for GHG emissions abatement including (i) a uniform global carbon tax, (ii) the development of Carbon Dioxide Removal (CDR) technology with the introduction of Bioenergy Carbon Capture and Storage (BECCS), and (iii) emissions reductions from land-use change. In general, results for each policy package/scenario examined in this chapter are deviations from the Historical Trends scenario in terms of percentage change or value change. The main focus is on the results of overall economic activities, energy consumption, emission levels, domestic material extractions (DE), physical (material) trade balance (PTB) and material productivity. These materials are categorized into biomass (crops, animal, forestry and fish), fossil fuels (coal, gas and oil), metals (ferrous metals and other metals), and non-metallic minerals (minerals and construction materials).

The chapter employs the Global Trade and Environmental and Resource Model (GTEM-Resource) – a multisectoral and multiregional recursive dynamic Computable General Equilibrium (CGE) model. GTEM-Resource is a hybrid macroeconomic CGE model that includes power produced by various fossil fuel and renewable-based technologies, and other technologies in the transportation and steel manufacturing sectors. The model includes interactions between almost all sectors (producers, traders, investors, households and governments) across world economies. Primary material demand is integrated into the model and the approach used in GTEM-Resource to project material use/demand is described in Schandl *et al.* (2020). The original GTEM-Resource model was developed from the original version of GTEM (Pant 2007) for various climate policy studies (Garnaut, 2011; Gunasekara *et al.* 2008; Harman *et al.* 2008). In the CGE literature, the GTEM model has also been used for various studies on material use projection (UNEP 2017; IRP 2019a; Hatfield-Dodds *et al.* 2017; Schandl *et al.* 2016, 2020). This chapter also uses the Global Trade Analysis Project (GTAP) database version 10 with a base year of 2014. This is the world economic database that represents the monetary flows of most sectors (e.g. industries, investors, importers, exporters, households, governments) in the world economy. The database contains 141 countries/regions, 65 industrial sectors, one household and one government representative group in each country. Each industry in a country/region pays for their inputs (e.g. materials, energy, labour, capital) and taxes, while it has revenues from selling their outputs. Households get income from supplying their labour and pay for what they purchase, including taxes. Governments collect taxes as their revenue and pay for their services, subsidies, etc. There is also bilateral trade data that connects these countries' economies. In this study, 141 regions are aggregated into 40 regions including eight countries from the West Asia region (Bahrain, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, UAE and the rest of West Asia). Of these, Iraq, Lebanon, Palestine, Syrian

Arab Republic; and Yemen are included in the "rest of West Asia" region because these individual countries are not available in the GTAP database. The GTAP global multiregional input-output (MRIO) database is the most detailed global database and holds data for 121 countries representing 98 per cent of global GDP and 92 per cent of the global population as well as 20 aggregate regions one of which is rest of West Asia. In the absence of national input-output and supply and use tables for many countries they cannot be represented in the multiregional input-output as individual countries. This may change in the future if such information becomes available and can be integrated into the GTAP database.

The first section of this chapter describes the baseline Historical Trends scenario and provides projections for material extraction, productivity and the regional material trade balance along with total GHG emission projections. The next section includes an outline of the two policy packages and the assumptions in the Towards Sustainability pathway/scenario. This is followed by a discussion of key findings on prospects for resource extraction, productivity, GHG emissions and their implications for economic performance based on those policy proposals. Essential technical information is provided at the end of the chapter, with additional material provided in a separate technical annex.

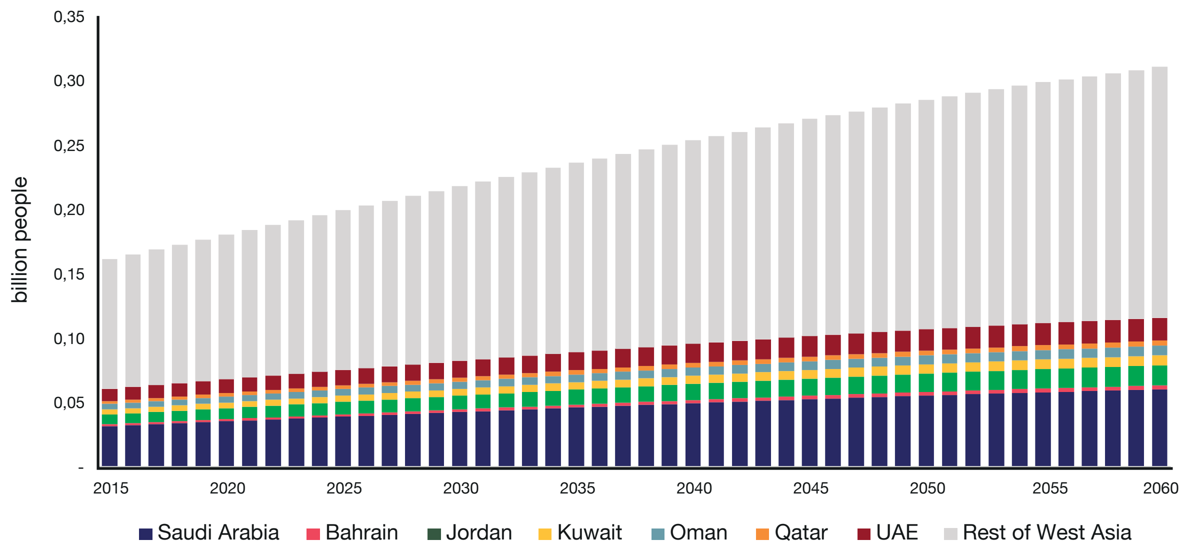
3.1 OVERVIEW OF THE BASELINE HISTORICAL TRENDS SCENARIO

The Historical Trends scenario provides projections for the world economy including the West Asia region from 2015 to 2060. The projections relate to resource use, GHG emissions, economic development and population growth based on assumptions following historical trends and the Shared Socioeconomic Pathway 2 (SSP2) – the "middle of the road" narrative (O'Neill *et al.* 2017).

3.1.1 POPULATION AND ECONOMIC GROWTH

The discovery of oil and the subsequent rise in wealth and education led to a large growth in population and living standards in West Asia (UNEP 2016b). Based on SSP2, the population of West Asia is projected to grow from 160 million people (2.2 per cent of the global population) in 2015 to 310 million people (3.3 per cent) in 2060. Under Historical Trends, the population in West Asia will grow by a compound annual growth rate of 1.5 per cent over the period. This projected increase in population in West Asia would lead to a significant increase in material demand and GHG emissions, indicating the need for vital policy actions to decouple environmental consequences. The "rest of West Asia" region (consisting of Iraq, Lebanon, Palestine, Syrian Arab Republic; and Yemen) accounts for 62 per cent (200 million people) of the West Asia population, followed by Saudi Arabia (20 per cent or 60 million people), while Bahrain and Qatar are the least populous (**Figure 18**).

FIGURE 18. POPULATION BY COUNTRY IN WEST ASIA IN THE HISTORICAL TRENDS SCENARIO IN 2015–2060 (BILLION PEOPLE)



SSP2 also projects strong GDP growth for West Asia, increasing from $2.5 trillion in 2015 to $10 trillion in 2060 (based on the 2014 dollar value), with an annual compound growth rate of 3.2 per cent (**Figure 19**). Under Historical Trends, this translates into growth of between 3 and 4 per cent of global GDP during this period. There are, however, significant disparities in West Asia's economic performance. Some of the region's countries, particularly GCC countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, UAE), are among the world's highest-income nations with large GDPs, while other countries, such as Yemen, are among the lowest-income countries and have stagnant economies (UNEP 2016b). According to the Historical Trends scenario, the four major economies of GCC countries, namely Kuwait, Qatar, Saudi Arabia and UAE and the "rest of West Asia" region account for an average share of the total West Asia region's GDP of 6 per cent, 9 per cent, 30 per cent, 15 per cent and 34 per cent respectively during 2015 to 2060 (Figure 19). Consistent with the Historical Trends scenario, the highest yearly average GDP per capita (2014 dollar prices) is recorded by Qatar ($130,082) followed by the UAE ($61,325) and Kuwait ($61,189) (**Figure 20**). The average per capita GDP in these countries is well above the world average per capita GDP ($18,307) during 2015 to 2060. However, the average per capita GDP in the "rest of West Asia" region is below the world average, at an average of $13,234 per person.

Oil and gas exports are the main sources of income for the West Asia region, particularly the GCC subregion (UNEP 2016b). In the West Asia region, most economies such as Qatar, Kuwait, and Saudi Arabia are fossil fuel-based with the largest parts of their revenues derived from fossil fuel production and exports (Dellink *et al.* 2017). Therefore, oil and gas extraction make a major contribution to West Asia's total GDP, representing over 40 per cent of GDP in GCC countries, with the exception of Bahrain and the UAE (Ahmed 2021). The discovery of oil has led to economic prosperity, not only in the GCC countries where most of the oil is found but also in other countries in West Asia that depend on remittances from their nationals working in the economic sectors of the GCC countries (UNEP 2016a).

Oil demand and prices are, however, influenced substantially by global macroeconomic conditions (IMF 2017). Therefore, in West Asia, the economies are highly correlated with global macroeconomic trends (Deloitte 2020). West Asia has been greatly influenced by global oil prices that ideally reflect a balance of global demand and supply (UNEP 2016b). For instance, slow economic growth in China and a dramatic rise in US oil-shale production caused oil prices to decline by 60 to 70 per cent in 2015 (UNEP 2016b). Thus, the revenues of these countries are linked to the market price of oil, and GDP projections in West Asia consequently reflect global energy market dynamics (Dellink *et al.* 2017).

FIGURE 19. ECONOMIC ACTIVITY (GDP) BY COUNTRY IN WEST ASIA IN THE HISTORICAL TRENDS SCENARIO IN 2015–2060 (BILLION US$, 2014 PRICES)

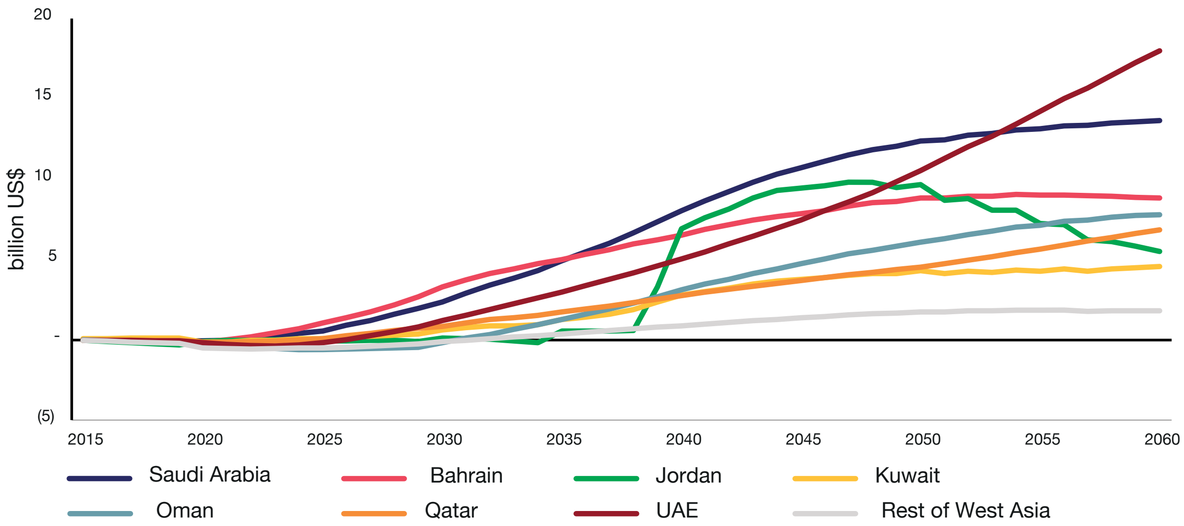
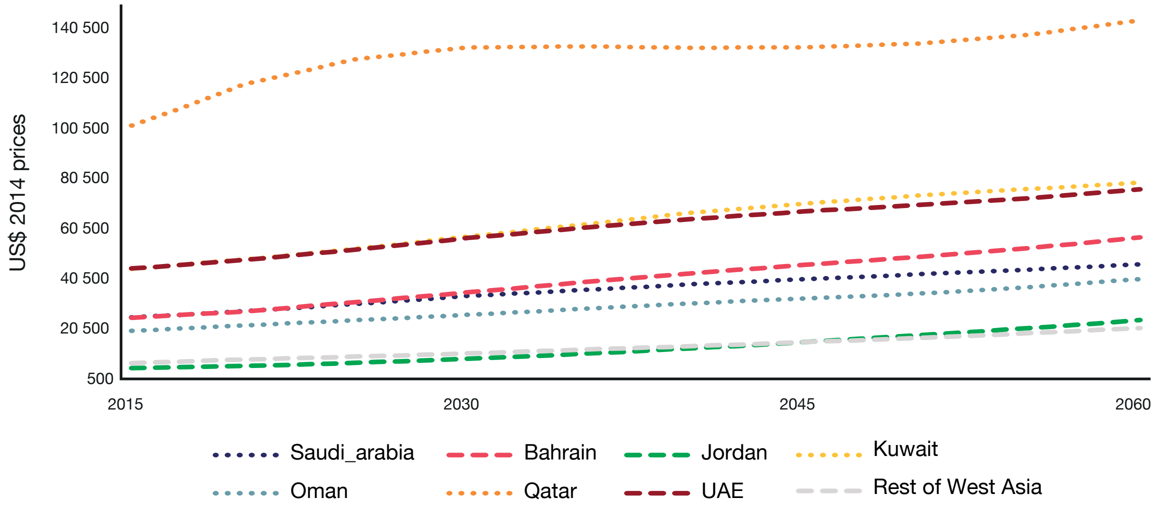


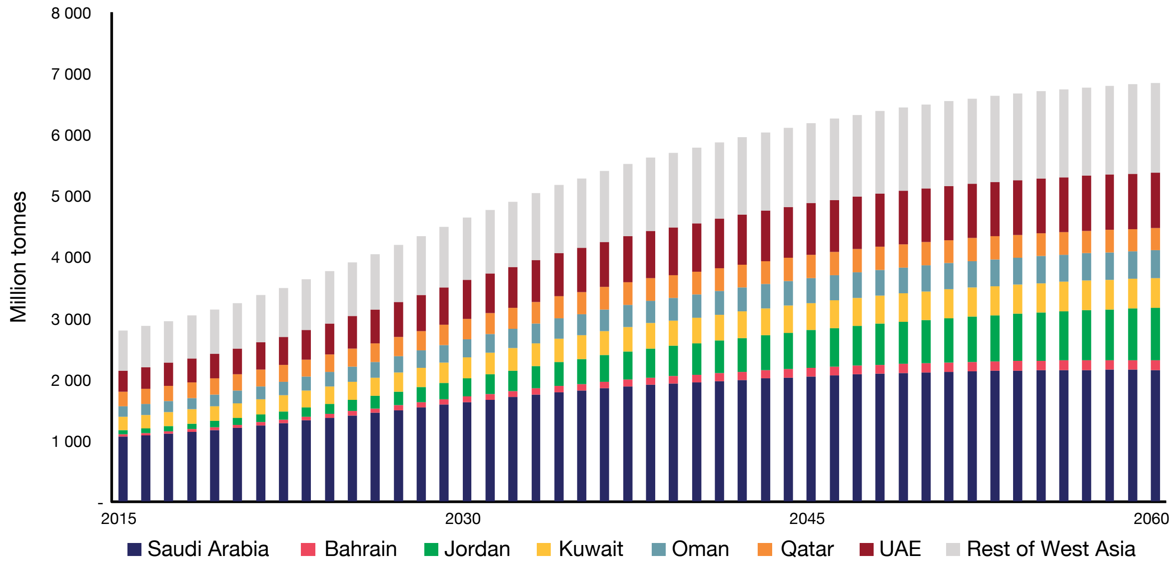
FIGURE 20. GDP PER CAPITA BY COUNTRY IN WEST ASIA IN THE HISTORICAL TRENDS SCENARIO IN 2015–2060 (US$, 2014 PRICES)



3.1.2 HISTORICAL TRENDS OUTLOOK FOR MATERIALS

Growing economies require more materials for production and consumption to improve infrastructure, ensure manufacturing capacity, increase human well-being and reduce poverty in the development process (IRP 2017). Our projections show that material extractions in West Asia make up 6.6 per cent of global material extractions in 2060, with domestic extraction increasing from 2.8 billion tonnes in 2015 to 6.8 billion tonnes in 2060 (**Figure 21**). This is equivalent to an annual average rate of 2 per cent growth. This growing material extraction in West Asia is higher than the population growth rate but lower than the economic growth in the region. This is because of an improvement in productivity/efficiency leading to higher economic growth compared with the growth rate of material extraction. In addition, West Asia will achieve strong growth in material extraction before 2050 but its domestic extraction will slow down to an annual growth of 0.5 per cent in 2050 to 2060.

FIGURE 21. MATERIAL EXTRACTION BY COUNTRY IN WEST ASIA IN THE HISTORICAL TRENDS SCENARIO IN 2015–2060 (MILLION TONNES)



Saudi Arabia is a major contributor to this growth, representing almost 30–50 per cent of domestic material extraction in West Asia over the period. However, the Saudi Arabia share of material extraction in West Asia is gradually declining because of strong material extraction growth in other West Asian countries, such as Jordan, the UAE and the "rest of West Asia" region. Figure 22 shows material extraction in Saudi Arabia increasing from 1 billion tonnes to 2.1 billion tonnes between 2015 and 2060, mainly due to the growth of non-metallic minerals. Although Saudi Arabia owns 21 per cent of global crude oil reserves (4 per cent for natural gas), and is the largest owner of resources and the world's largest petroleum exporter (OAPEC 2020), the outputs of these sectors in Saudi Arabia over this period are relatively constant. However, the projections under Historical Trends show that Saudi Arabia will still be responsible for a 35 per cent share of total regional crude oil extraction in 2060.

On the other hand, domestic material extraction in the UAE will nearly triple by 2060, from 0.34 billion tonnes in 2015 to 0.9 billion tonnes in 2060. Material extractions in other major countries such as Qatar and Kuwait are projected to increase from 0.24 and 0.21 billion tonnes in 2015 to 0.36 and 0.48 billion tonnes in 2060, respectively. The "rest of West Asia" region accounting for more than 20 per cent of total domestic extraction in West Asia each year is expected to increase from 0.7 billion tonnes in 2015 to 1.5 billion tonnes in 2060 (**Figure 22a**).

Figure 22a illustrates Historical Trends of material extractions by major material categories (biomass, fossil fuel, metal ores and non-metallic minerals) that support growing economies in West Asia. The extractions of these major material categories in West Asia collectively grow at a compound annual growth rate of 3.4 per cent during 2015 to 2030 then at 1.3 per cent per annum during 2030 to 2060. It is important to note that the material composition of domestic extraction in West Asia will shift drastically from fossil fuel resources to non-metallic minerals and thus dominate the total quantity of resource extraction (**Figure 24**).

Non-metallic mineral use in the construction sector is the dominant group of material demand in West Asia and domestic extraction from this category is expected to increase from 1.3 billion tonnes in 2015 to 5.1 billion tonnes in 2060 with a compound annual growth rate of 5.7 per cent from 2015 to 2030 and 1.8 per cent from 2030 to 2060 (**Figure 22a**). This group of materials contributes 45 per cent of total material extraction in 2015 and the share will increase to 74 per cent in 2060 due to its strong growth while total fossil fuel extractions remain relatively constant over the period (**Figure 22b**). This demonstrates a higher amount of non-renewable natural resource extraction in West Asia and is mainly attributed to the fast-growing use of non-metallic minerals in the construction sector, particularly the building and road infrastructure sectors in high-income GCC countries such as Jordan, Saudi Arabia and the UAE. These three countries collectively extract more than 50 per cent of the total non-metallic mineral resources in West Asia for their construction activities.

FIGURE 22 (a). MATERIAL EXTRACTION BY CATEGORY OF MATERIALS IN WEST ASIA IN THE HISTORICAL TRENDS SCENARIO IN 2015–2060 (MILLION TONNES)

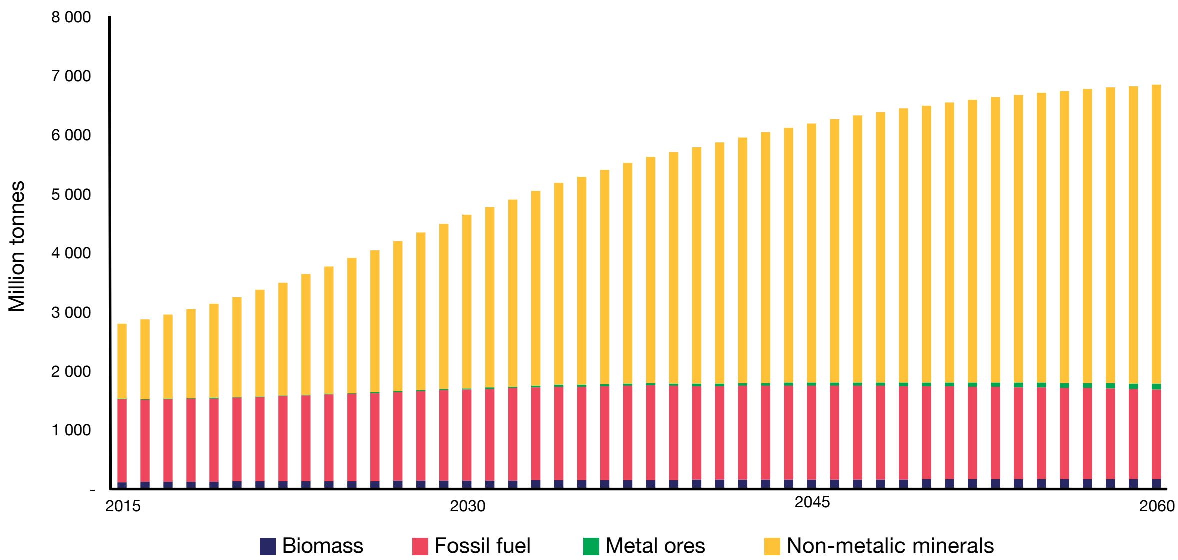
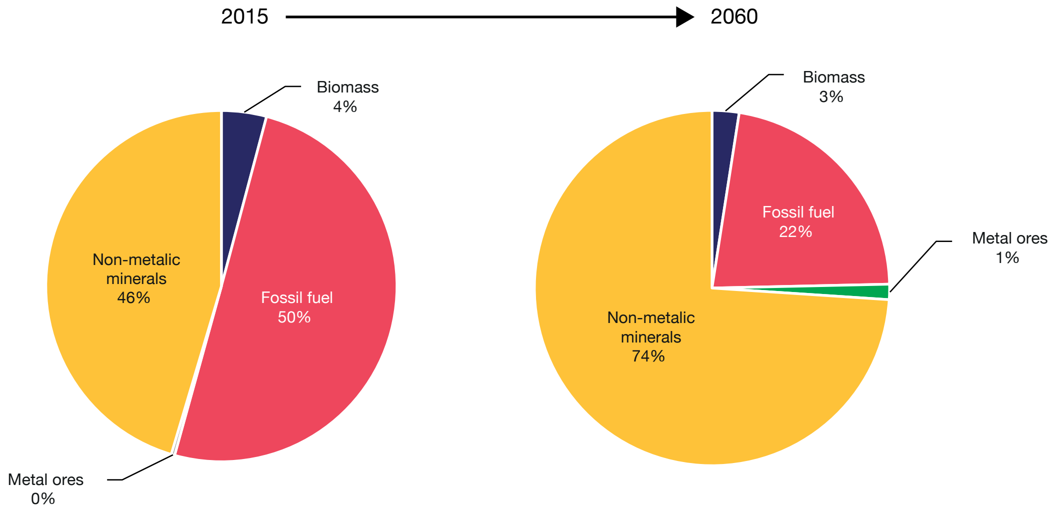


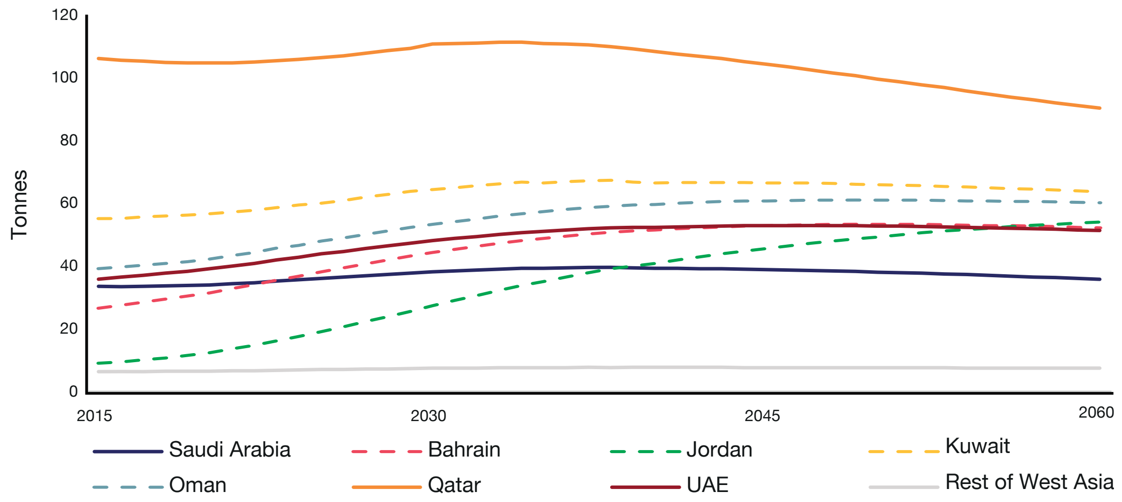
FIGURE 22 (b): COMPOSITION OF DOMESTIC MATERIAL EXTRACTION IN WEST ASIA IN THE HISTORICAL TRENDS SCENARIO IN 2015–2060 (MILLION TONNES)



West Asia has extensive oil and gas resources. It dominates the world in this sector, holding 55 per cent of world oil reserves and around 26 per cent of world gas reserves (OAPEC 2020). Production of these resources plays a vital role in the region's economic growth. However, oil extraction in West Asia will most likely remain steady by producing 1.5 billion tonnes in 2015 and 1.7 billion tonnes in 2060 with a compound annual growth rate of only 0.8 per cent in 2015–2030 and negative 0.03 per cent growth in 2030–2060. Moreover, the Historical Trends scenario suggests that the share of fossil fuel extractions in the West Asia region will decline from 50 per cent in 2015 to 22 per cent in 2060, mainly due to a persistent trend in oil extraction throughout the period and an increasing trend in metals and non-metallic minerals extraction (**Figure 22b**). This can be attributed to baseline fuel efficiency and material efficiency assumptions, which boost higher output levels with the same amounts of energy inputs. In contrast, gas extraction in the region is expected to grow from 3.2 billion tonnes in 2015 to 4.8 billion tonnes in 2060 to support the energy transition from coal- and oil-based to gas-based electricity generation technology. The Historical Trends projects that by 2040 there will only be gas-based electricity generation technology in the region, while coal- and oil-based generation will no longer be in operation. Nonetheless, the share of gas extraction comprises less than 20 per cent of total fossil fuel extraction in West Asia.

Figure 23 illustrates the Historical Trends of domestic material extractions on a per capita basis for each country in West Asia. If the Historical Trends continue, per capita resource extraction in the whole West Asia region will grow at an annual compound rate of 0.5 per cent. Qatar is recorded as the highest per capita material-producing country in the region with a volume of 106 tonnes per person in 2015. This is more than twice the amount of per capita material extraction than in most other large economies, such as Kuwait, Saudi Arabia and the UAE. However, results show that there would be 90 tonnes per person in Qatar in 2060, a 15 per cent decline compared with 2015 because of high growth in the population relative to the growth of material extraction. The reason behind this is that the GDP projection for Qatar in 2015–2060 following the SSP2 is much smaller than the GDP growths in other countries in West Asia (**Figure 20**). In addition, Qatar already presents a well-established infrastructure that can service the economy. As a result, Qatar would require fewer materials for its economic development which, combined with relatively strong population growth, will result in the eventual decline of its per capita material extractions. Saudi Arabia and the "rest of West Asia" show relatively constant per capita material extractions due to similar growth in population and material extractions. In addition, Jordan is projected to achieve relatively high per capita material extraction from 9 tonnes per person in 2015 to 54 tonnes per person in 2060. Bahrain, Kuwait, Oman and the UAE also experience high growth in per capita material extractions to support their strong economic growths.

FIGURE 23. PER CAPITA MATERIAL EXTRACTION BY COUNTRY IN WEST ASIA IN THE HISTORICAL TRENDS SCENARIO IN 2015–2060 (TONNES)



Strong growth in primary materials and commodities made from biomass, fossil fuels, metal ores and non-metallic minerals will continue to support the global economy. The global economy is now more dependent on the trade in materials than in the past and this growing material demand is supplied by low-income and middle-income regions, indicating the outsourcing of local impacts of resource extraction by producing primary exports for high-income countries (IRP 2017). West Asia is one of the major global export sources for materials, apart from biomass, and accounted for 15 per cent of global exports in 2015.

Figure 24 shows the physical trade balance by major material categories in West Asia, which is calculated by subtracting physical exports from physical imports. Net exports are represented as negative numbers, indicating higher exports compared with imports, while net imports show positive numbers, having fewer exports than imports. West Asia's physical trade balance is mainly dominated by fossil fuels, which are the region's net exports. The net export of fossil fuels from the region is projected to decline slightly from 2040 to support economic growth in the region. In addition, according to the IMF (2020), most GCC countries tend to implement energy subsidy cuts, which increase the prices of electricity, petrol and other fuels in the domestic markets resulting in fewer export opportunities. Biomass, metal ore and non-metallic minerals are net imports in the region. Major growth in non-metallic minerals occurs until 2030, growing at a yearly average rate of 6.6 per cent from 0.14 billion tonnes of imports in 2015 to 0.36 billion tonnes of imports in 2030. Consistent with the Historical Trends scenario, biomass and metal ore remain as net imports and the growths are constant during this period.

Figure 25 illustrates that most countries in West Asia increase their material imports relative to exports by having higher positive values (and/or less negative values) in their trade balance during 2015–2060. In other words, most countries in West Asia move towards becoming net importers over the period. This is because domestic extractions of fossil fuels in the region are relatively constant over the period 2015–2060 leading to a low fluctuation in exports of these commodities, while the economies of West Asian countries will grow strongly, resulting in higher import levels accordingly. As a result, the material trade balances of these countries will move towards imports. Jordan is exempt because of relatively strong growth in non-metallic exports; hence, it will gradually become a net exporter. Saudi Arabia, in particular, is the largest net exporter in West Asia in 2015–2030, but Jordan then becomes the dominant net exporter in the region, reaching a net export of 562 million tonnes of material in 2060. Saudi Arabia, on the other hand, reduces its net export from 299 million tonnes in 2015 to 20 million tonnes in 2060 due to higher import levels of non-metallic minerals.

FIGURE 24. PHYSICAL TRADE BALANCE (IMPORTS–EXPORTS) BY MAJOR MATERIAL CATEGORIES IN WEST ASIA IN THE HISTORICAL TRENDS SCENARIO IN 2015–2060 (MILLION TONNES)

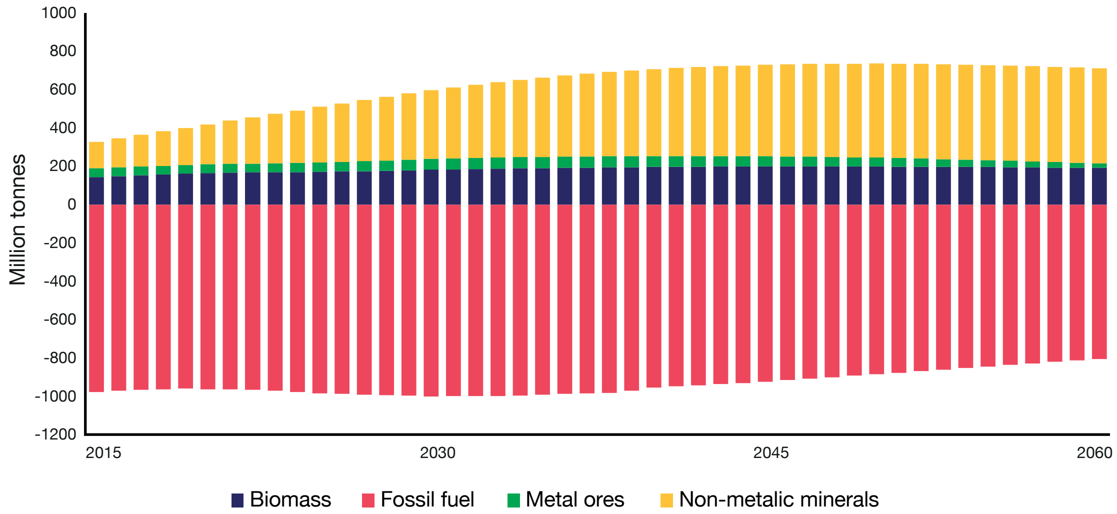


FIGURE 25. PHYSICAL TRADE BALANCE BY COUNTRY IN WEST ASIA IN THE HISTORICAL TRENDS SCENARIO IN 2015–2060 (MILLION TONNES)

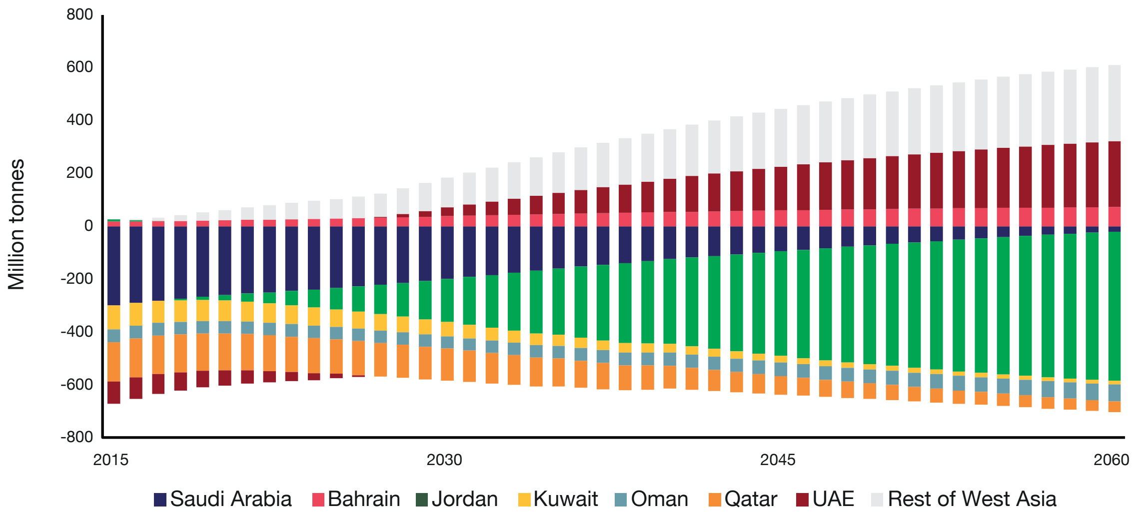
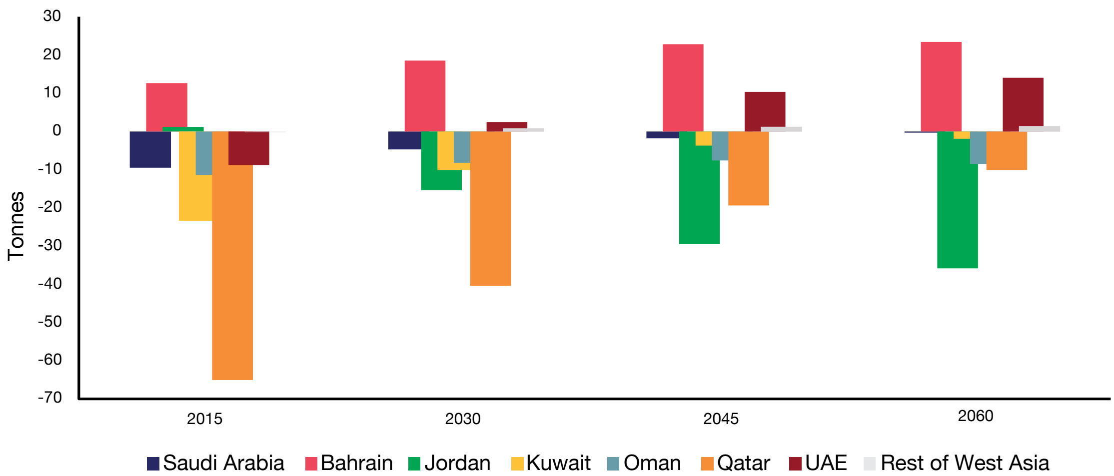


FIGURE 26. PER CAPITA PHYSICAL TRADE BALANCE BY COUNTRY IN WEST ASIA IN THE HISTORICAL TRENDS SCENARIO IN 2015–2060 (TONNES)



Two other large economies in West Asia, Qatar and Kuwait are also net material exporters in the region, yet their exports will decline from 149 and 90 million tonnes in 2015 to 40 and 14 million tonnes in 2060, respectively (**Figure 25**). Per capita material exports in Qatar and Kuwait will also decline from 65 and 23 tonnes per person in 2015 to 10 and 1.8 tonnes per person in 2060, respectively (**Figure 26**). These two countries are net material exporters merely because of oil and gas exports, which surpass the import quantities of other materials. According to our projections, oil and gas exports in these two countries will remain stable over the period, but imports of other materials will increase, leading to lower levels of trade balance (total import minus total export). The "rest of West Asia" region and the UAE experience high growth in net imports (**Figure 25**). The UAE turns from being a net exporter to a net importer after 2026. Net imports in the UAE will grow by a relatively small margin until 2030, with an average of around 11.6 million tonnes of imports. However, material imports in the UAE will grow from 33 million tonnes in 2030 to 249 million tonnes in 2060 (**Figure 25**). Per capita material net exports of 8.8 tonnes per person in the UAE in 2015 will become 14tonnes of per capita material imports in 2060 (**Figure 26**). This can mainly be attributed to constant growth in oil exports, which acts as an exclusive contributor to the UAE's export composition, while major increases in non-metallic mineral and metal imports are the result of its rapidly growing construction sector. The outcomes in Figure 25 are also represented in Figure 26, which outlines the results of the per capita trade balance. Qatar will substantially reduce its per capita trade balance from a negative value of 65 million tonnes in 2015 to a negative value of 10 million tonnes in 2060, while Qatar will strongly improve its net exporting position by having a negative value of 36 million tonnes in 2060 compared with a positive value of one million tonne in 2015.

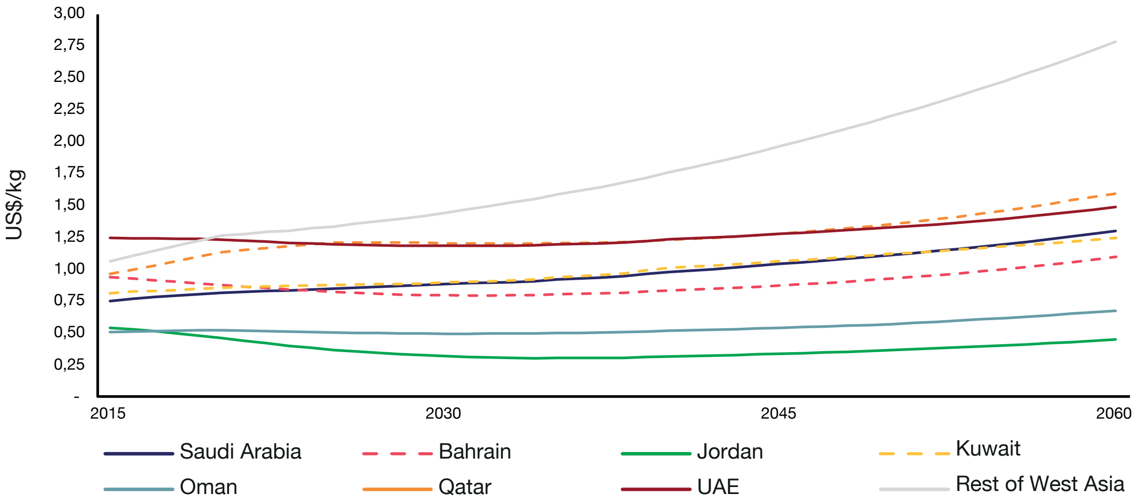
It is common that urbanization and industrialization require large amounts of materials to develop the infrastructure and manufacturing needed to fuel economic growth, increase human well-being and reduce poverty, thus generating material expenses which surpass GDP growth (IRP 2017).

To bridge the gap between material needs and GDP growth, increased material productivity/efficiency can help manage a growing demand for natural resources and related environmental consequences while ensuring sustainable economic growth. Indeed, increasing material efficiency is a key factor for countries to reach the 1.5° C target in the Paris Agreement (IRP 2020).

Figure 27 demonstrates material productivity (2014 dollar prices per kg) in West Asia, calculated as the quantity of materials required to produce one unit of output (GDP). The Historical Trends scenario projects slow growth in improving material productivity in West Asia. In 2015–2033, our projections show a decline in material productivity from $0.83 per kg to $0.69 per kg (–0.1 per cent per year) because of a period of fast growth in material demand for infrastructure build-up in the early stages, compared with significantly lower GDP growth. Once infrastructure development is achieved, the region will experience faster GDP growth with less material demand, thus improving material productivity. This trend can be seen in the slightly improved compound annual growth rate of 0.4 per cent for 2033 to 2050 ($0.69 to $0.83 per kg). Over 2050 to 2060, material productivity increases by 1.9 per cent per annum, reflecting the overall productivity rising from $0.83 per kg to $1.00 per kg.

Material productivity is highest in the "rest of West Asia" region, showing growth from $1.06 per kg in 2015 to $2.77 per kg in 2060 (**Figure 29**). This growth will mainly be due to GDP growth rates (4 per cent per annum) exceeding rates of material extraction growth (1.8 per cent per year). Almost the same material productivity average per annum is projected for Qatar and the UAE (i.e. $1.26 per kg during 2015–2060). To date, Saudi Arabia has required a large amount of material extraction and is one of the countries reported to have the highest GDP in West Asia, but low material productivity is recorded due to fast-growing material extraction compared with GDP growth. Material productivity in Saudi Arabia is less than that in other small countries in the region, for example Bahrain and Kuwait (**Figure 27**).

FIGURE 27. RESOURCE PRODUCTIVITY (REAL GDP (2014 $) PER KG OF MATERIAL EXTRACTION) BY COUNTRY IN THE HISTORICAL TRENDS SCENARIO IN 2015–2060



3.1.3 HISTORICAL TRENDS OUTLOOK FOR GHG EMISSIONS

A growing world economy requires more materials for production and consumption, which results in higher levels of natural resource depletion, waste, emissions and climate change consequences (UNEP 2016a). The production of materials is a significant source of GHG emissions (IRP 2019a, 2020). Around two-thirds of the total global GHG emissions relate to materials management activities, fossil fuel combustion or the production of iron and steel (OECD 2018). In addition to fossil fuel extraction and combustion, IRP (2017) found that steep increases in demand for metal ores, such as iron, have also contributed to sharp rises in GHG emissions.

The economic growth of many countries in West Asia depends heavily on emission-intensive fossil fuel resources. Despite being responsible for a quarter of global oil extraction under the Historical Trends scenario, West Asia is not a major contributor to global GHG emissions. West Asia is responsible for only 3.8 per cent of total global emissions in 2015 and this share is expected to increase to 6.7 per cent by 2060. This is equivalent to 1.5 billion tCO_2eq in 2015 and 5 billion tCO_2eq in 2060 (**Figure 28**).

As the world's largest oil and gas exporter, Saudi Arabia is responsible for the largest share of total GHG emissions in West Asia, due to production activities. Saudi Arabia accounted for 36 per cent of total regional GHG emissions in 2015, and this share will increase to 38 per cent in 2060, thus remaining a major GHG emitter in the region. In Historical Trends, the GHG emission levels in Saudi Arabia are estimated to increase from 0.57 billion tCO_2eq in 2015 to 1.9 billion CO_2eq in 2060, equivalent to an average 2.7 per cent annual growth rate (**Figure 28**). Kuwait, Qatar and the UAE are the other major GCC countries contributing to regional GHG emissions. Figure 28 outlines that the largest GHG emitters following Saudi Arabia are the UAE, followed by Qatar and Kuwait. These three countries contribute a combined share of 30 per cent of regional GHG emissions, increasing from 0.47 billion tCO_2eq in 2015 to 1.5 billion tCO_2eq in 2060. Significant growth in GHG emissions is also forecast for other small countries in the region such as Bahrain, Jordan and Oman. By 2060, these three countries' GHG emissions will increase by almost five times what they were in 2015, resulting in a combined amount of 0.15 billion tCO_2eq in 2015 and 0.74 billion tCO_2eq in 2060. Overall, it is predicted that there will be a drastic decline in emission levels during 2050 to 2060 relative to 2015 to 2035. This is equivalent to a 36.9 per cent decline in emissions in West Asia, contributed largely by Qatar (41 per cent), Saudi Arabia (36 per cent) and Kuwait (34 per cent), mainly due to improved regional productivity/efficiency in fossil fuel extraction from 2050 to 2060.

FIGURE 28. GHG EMISSIONS BY COUNTRY IN WEST ASIA IN THE HISTORICAL TRENDS SCENARIO IN 2015–2060 (MILLION TONNES OF CO_2EQ)

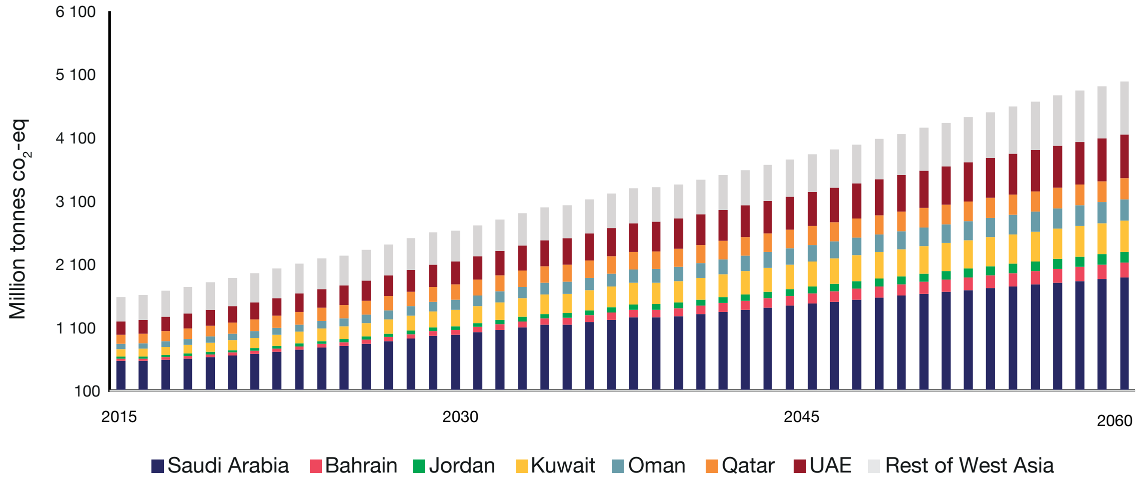
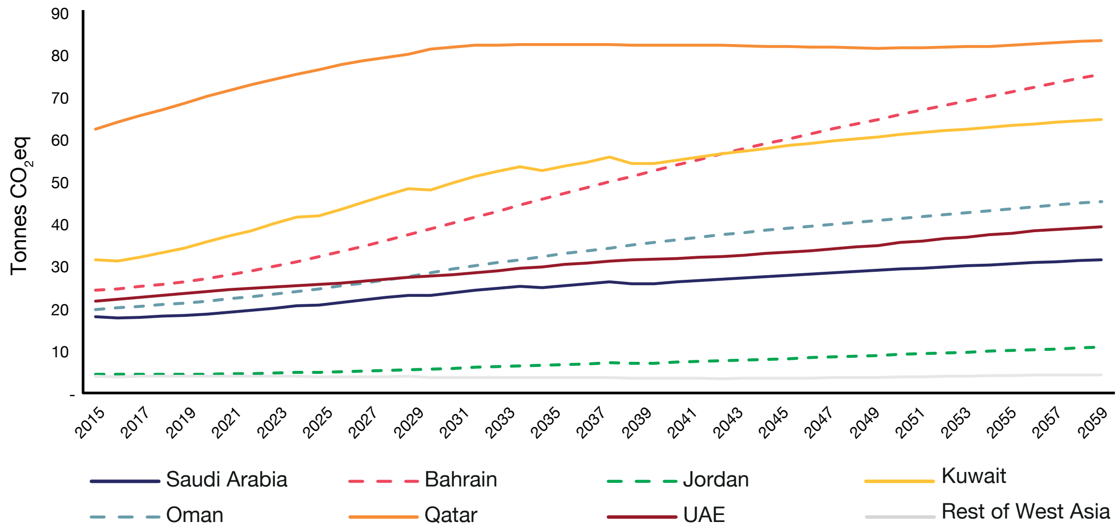


FIGURE 29. PER CAPITA GHG EMISSIONS BY COUNTRY IN WEST ASIA IN THE HISTORICAL TRENDS SCENARIO IN 2015–2060 (TONNES OF CO_2EQ)



Even if West Asia contributes only a small share of global GHG emissions, the region is one of the world's largest contributors of GHG emissions on a per capita basis. Per capita GHG emission levels in most countries in West Asia, including the GCC and small countries, exceed the global average by relatively large percentages. For example, the per capita GHG emission level (a ratio of all country's GHG to total population in such a country) in Qatar was ten times higher than the global average level in 2015 totalling 62.34 tCO_2eq per person (**Figure 29**), while the global average level was only 5.68 tCO_2eq per person. In 2015, Kuwait was reported as the second largest per capita GHG emissions emitter (31.34 tCO_2eq) in the region, followed by Bahrain (24.31 tCO_2eq), the UAE (21.65 tCO_2eq), Oman (19.74 tCO_2eq) and Saudi Arabia (18 tCO_2eq). Per capita GHG emission levels in West Asia are expected to grow at a yearly average rate of 2 per cent as compared with the global per capita GHG emissions growth rate of 0.7 per cent per annum during 2015 to 2060. According to UNEP (2016b), the fast-growing per capita GHG emissions in West Asia are a result of growing total energy consumption. This can be linked to population, economic activity, energy fuel mix and the efficiency of water and electricity use.

3.2 TOWARDS SUSTAINABILITY OUTLOOK FOR RESOURCE USE AND GHG EMISSIONS

The Towards Sustainability outlook/scenario introduces comprehensive sets of policies to improve resource efficiency and mitigate GHG emissions in West Asia and provides projections for sustainable future pathways. It consists of two policy packages, the Resource Efficiency and Climate Policy packages, also called scenarios if the impacts are reported separately from the Towards Sustainability scenario (**Table 2**). In this study, the modelling framework and the approach used in the Towards Sustainability outlook follow the Global Resource Outlook 2019 (IRP 2019a). To include the West Asia countries, a new base-year data set is used (a base year of 2014 instead of 2007) along with updated baseline economic and population growth, and energy and fuel efficiency assumptions for 2015 to 2060 with a new regional disaggregation. More details on scenario definitions and modelling assumptions are provided in the technical notes and IRP (2019a).

The Resource Efficiency policy package/scenario addresses material productivity (GDP per unit of material use) (Hatfield-Dodds *et al*. 2017). This scenario attempts to explore the positive impacts of three sets of policy instruments regarding resource efficiency in West Asia (i.e. resource efficiency innovation strategies, ad valorem resource extraction taxes and a leftward shift in demand for virgin resources) (Table 2). These measures have very different impacts on natural resource extraction, material use, productivity and overall economic activity.

In the Resource Efficiency scenario, the first instrument (resource efficiency innovation and improvements) reduces the quantity of resource inputs required for a given volume of output, which can lower the cost of the direct and indirect natural resource use and of the final product. For the second instrument, the resource extraction tax approach involves ad valorem (value-based) taxes which are imposed on all-natural resource extractions. Extraction taxes are modelled to increase by 10 per cent in 2020 and afterwards an annual increase of 1.5 percentage points until reaching a cumulative 70 per cent in 2060 for low- and medium-income countries, while a higher tax rate for high material supplied–high-income regions is imposed (i.e. 12.5 per cent in 2020 with an increase of 1.9 percentage points annually until reaching a cumulative 87 per cent in 2060). This would increase the price of natural resources relative to other inputs and slow the growth in natural resource use. Regarding the third instrument, an exogenous resource demand shift (i.e. -0.5 per cent annually since 2020 for low- and medium-income regions and -0.8 per cent for high-income regions) changes the demand curve leftward because of changes in regulations, planning and procurement policies. This would progressively lower resource extraction and improve resource productivity. The implementation of resource efficiency policies was expected to bring economic growth, social development and provide net economic benefits, leading to environmental sustainability. However, poorly designed and badly implemented strategies could slow economic growth and cause net economic costs to the region. Within countries, this will likely translate to wider wealth gaps between rich and poor, increased gender inequalities with women and girls being left further behind and reduced human rights to a clean and healthy environment for all.

The Climate Policy scenario involves three measures for GHG abatement including: a uniform global carbon tax; the development of Carbon Dioxide Removal (CDR) technology with the introduction of Bioenergy Carbon Capture and Storage (BECCS) and the reduction of emissions from land-use change (**Table 2**). The carbon tax levy is implemented by imposing a gradual annual increase of carbon tax from \$15/tCO_2eq in 2020 to \$437/tCO_2eq in 2060, equally applied to all countries and to all emission sources. The CDR technology is assumed to remove 0.3 Gt of carbon by 2023 and requires a specified amount of electricity related to the technologies employed. The electricity demand for CDR is kept constant from 2023 onwards. Negative emissions achieved from land-use change (i.e. carbon plantings) are implemented as a reduction in land and natural resource supply. Input data for the relevant simulations (land supply) is based on the output derived from the Global Biosphere Management Model (GLOBIOM) which follows the SSP2 scenario (IRP 2019a).

Following the approach used in the previous reports, the Resource Efficiency policy package/scenario was combined with the Climate Policy package/scenario to explore potential policy interactions. This in turn will provide results for the Towards Sustainability scenario (see IRP 2019a).

Implementing these three policy packages/scenarios will help shift the West Asia region from the Historical Trends to the Towards Sustainability pathway. The following section reports the key findings for sustainable resource use, climate mitigation and decoupling economic growth under each scenario for West Asia.

TABLE 2. POLICY INSTRUMENTS USED IN EACH SCENARIO IN THE TOWARDS SUSTAINABILITY OUTLOOK

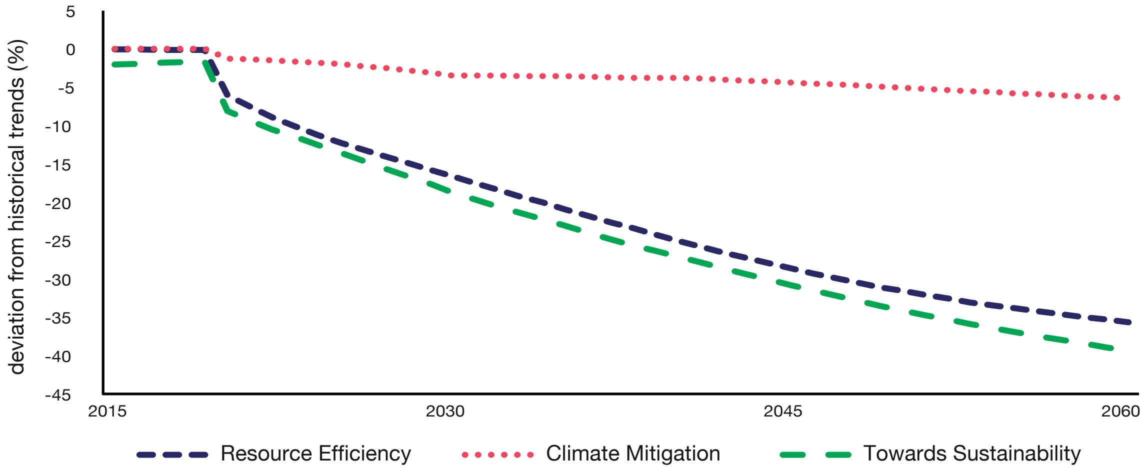
POLICY SCENARIOS	POLICY INSTRUMENTS	INSTRUMENT DESCRIPTION
RESOURCE EFFICIENCY	Resource efficiency innovation strategies	Policies such as public research programmes, incentives for innovation and technology adoption and support for private R&D, demonstration projects and business incubators (with specific measures to ensure the consideration and inclusion of women and girls)
	Ad valorem resource extraction taxes	Low- and medium-income regions: 10 per cent in 2020 and increases 1.5 percentage points annually until reaching cumulative 70 per cent in 2060 High material supplied – high-income regions: 12.5 per cent in 2020 and increases 1.9 percentage points annually until reaching a cumulative 87 per cent in 2060
	Demand shifts	Low- and medium-income regions: –0.5 per cent per annum since 2020 High-income regions: –0.8 per cent per annum since 2020
CLIMATE MITIGATION	Uniform global carbon tax	Gradual increases of carbon price from $15/t$CO_2$eq in 2020 to reach $437/t$CO_2$eq in 2060
	Development of CDR technology	Develop a pathway of electricity demand from biomass in BECCS technology begun in 2015 to reach 0.3 Gt of carbon sequestered in 2023
	Land-use change	Implement land/natural resource supply shocks
TOWARDS SUSTAINABILITY	A combination of the Resource Efficiency & Climate Mitigation scenarios	------

Source: IRP (2019a)

3.2.1 SUSTAINABLE RESOURCE USE

The combined effects of resource efficiency and climate mitigation actions in the Towards Sustainability scenario would help reduce material extraction in West Asia at higher rates compared with the Historical Trends scenario (**Figure 30**). In comparison to the Historical Trends, the Towards Sustainability scenario forecasts 39 per cent less material extraction (equal to 4 billion tonnes) while the Resource Efficiency scenario alone forecasts a decrease of 35.6 per cent material extraction, avoiding 3.6 billion tonnes by 2060. The Climate Mitigation scenario has smaller impacts on this progress showing only a 6.4% reduction of the total material extraction reduction. However, by looking at the impact from the modelling results on individual material categories, Climate Mitigation actions will significantly slow oil and gas extraction in the region compared to other sectors. This is equivalent to avoiding 527 million tonnes of oil and gas, around 30 per cent less growth compared to the Historical Trends scenario in 2060 though the aggregate material extraction reduction is only at 6.4%. This would be possible through the introduction of negative emissions technologies and a uniform global carbon tax. The Towards Sustainability scenario will reinforce an additional 15.5 per cent less oil and gas extraction in West Asia because of the combined effects of resource efficiency and climate mitigation measures. The Towards Sustainability scenario also forecasts that per capita resource extraction will reduce at an annual average rate of 23.3 per cent compared to the Historical Trends scenario (equal to an average of 30.8 tonnes per person from the Historical Trends scenario to 23 tonnes per person in the Towards Sustainability scenario).

FIGURE 30. IMPACTS ON MATERIAL EXTRACTIONS IN WEST ASIA IN 2015–2060 IN THE RESOURCE EFFICIENCY, CLIMATE MITIGATION AND TOWARDS SUSTAINABILITY SCENARIOS – % DEVIATIONS FROM HISTORICAL TRENDS



Saudi Arabia is the largest oil and gas producer in the region (42 per cent of overall extraction) and would contribute 13.5 per cent less oil and gas extraction by 2060 if the country implemented the proposed climate mitigation policy package. As **Table 3** shows, under the Towards Sustainability scenario, total material extractions in Saudi Arabia are projected to be around 47 per cent lower compared with the Historical Trends scenario in 2060. This is a vital reduction as Saudi Arabia is one of the largest materials-producing countries on a per capita basis. Indeed, the Towards Sustainability scenario projects that per capita material extractions in Saudi Arabia will be reduced by almost 50 per cent in 2060, from 83 tonnes per person under the Historical Trends scenario to 44 tonnes in the Towards Sustainability scenario.

Other high-income countries such as Qatar and the UAE are also shown to extract 20 per cent fewer materials in the Towards Sustainability pathway compared with Historical Trends. Kuwait will even be able to reduce 36 per cent of material extraction in the Towards Sustainability scenario. Additionally, relatively small economies such as Jordan and Oman are shown to be very responsive to the Towards Sustainability policies, showing more than 45 per cent fewer material extractions compared with their continuing Historical Trends. Overall, all countries in the region can be seen to perform well under the Resource Efficiency policies. It is also evident that the Climate Mitigation polices will indirectly reduce the Historical Trends of resource extractions as well.

TABLE 3. IMPACTS ON MATERIAL EXTRACTIONS BY COUNTRY IN WEST ASIA IN 2060 IN THE RESOURCE EFFICIENCY, CLIMATE MITIGATION AND TOWARDS SUSTAINABILITY SCENARIOS – % DEVIATIONS FROM HISTORICAL TRENDS

COUNTRY	RESOURCE EFFICIENCY	CLIMATE MITIGATION	TOWARDS SUSTAINABILITY
SAUDI ARABIA	-43.5	-6.1	-45.0
BAHRAIN	-25.6	-10.6	-27.3
JORDAN	-35.7	-12.0	-48.5
KUWAIT	-27.6	-10.4	-36.2
OMAN	-44.9	-6.3	-47.2
QATAR	-14.5	-9.1	-23.6
UAE	-21.7	-6.0	-20.6
REST OF WEST ASIA	-19.8	-2.2	-20.2
TOTAL WEST ASIA	-35.6	-6.4	-39.3

The Resource Efficiency and Towards Sustainability scenarios project that resource productivity in West Asia will improve by 43.3 per cent and will be 52.5 per cent higher than the Historical Trends scenario in 2060, while the Climate Mitigation scenario indicates a similar but slightly smaller contribution to this growth (**Figure 31**). In addition, resource productivity begins to improve after 2030 with the introduction of extraction taxes and reduced demand for materials.

Compared with the Historical Trends scenario, material productivity in West Asia increases by an annual average of 14.2 per cent under the Resource Efficiency scenario and an annual average of 7.9 per cent under the Towards Sustainability scenario, indicating that resource efficiency policies contribute heavily to regional material productivity compared with climate mitigation policies. The greatest material productivity under the Towards Sustainability scenario is projected in Saudi Arabia, which is equivalent to a 114 per cent deviation from the Historical Trends scenario (**Table 4**). The Towards Sustainability scenario theoretically increases material productivity for small countries in the region by more than 100 per cent compared with the Historical Trends scenario (i.e. Jordan and Oman) (**Table 4**).

FIGURE 31. IMPACTS ON RESOURCE PRODUCTIVITY (2014 US$ PER KG OF MATERIAL EXTRACTION) IN WEST ASIA IN 2015–2060 IN THE RESOURCE EFFICIENCY, CLIMATE MITIGATION AND TOWARDS SUSTAINABILITY SCENARIOS (% DEVIATIONS FROM HISTORICAL TRENDS)

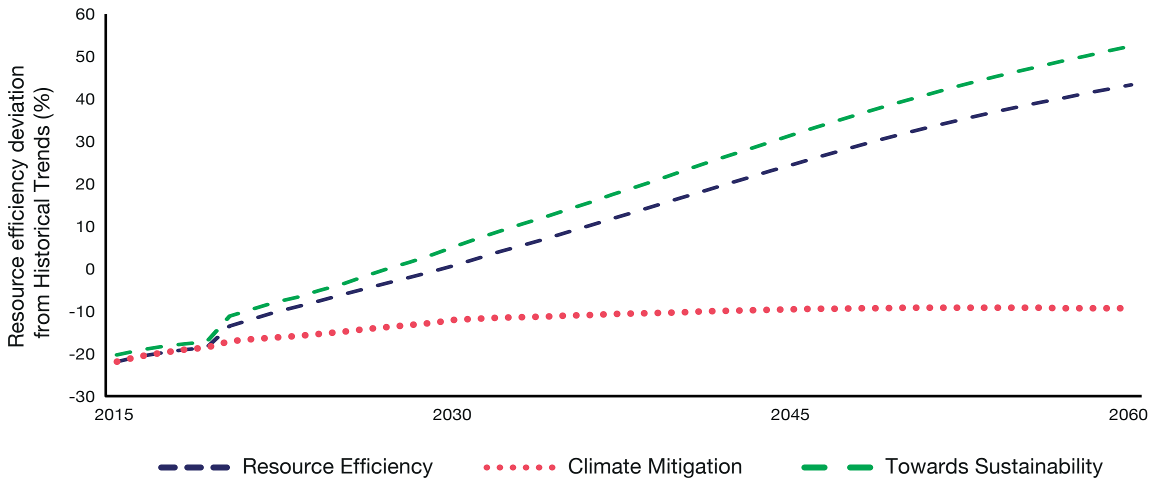


TABLE 4. IMPACTS ON MATERIAL PRODUCTIVITY BY COUNTRY IN WEST ASIA IN 2060 IN RESOURCE EFFICIENCY, CLIMATE MITIGATION AND TOWARDS SUSTAINABILITY SCENARIOS – % DEVIATIONS FROM HISTORICAL TRENDS

COUNTRY	RESOURCE EFFICIENCY	CLIMATE MITIGATION	TOWARDS SUSTAINABILITY
SAUDI ARABIA	102.7	5.6	114.3
BAHRAIN	48.9	13.3	49.8
JORDAN	45.2	25.1	104.9
KUWAIT	51.8	8.2	64.0
OMAN	100.5	-0.9	104.0
QATAR	31.7	8.2	39.9
UAE	47.7	3.9	48.6
REST OF WEST ASIA	25.1	1.3	27.6
TOTAL WEST ASIA	43.3	-9.4	52.5

3.2.2 IMPACTS ON GHG EMISSIONS

Improving material and energy efficiency is necessary to achieve environmental sustainability, but this will not suffice on its own (IRP 2017). GHG emission levels can be reduced as a co-benefit of improving resource efficiency and productivity, while mitigating GHG emission levels through explicit actions (UNEP 2016b). This section explores the exclusive as well as combined impacts of resource efficiency and climate mitigation policies on GHG emission abatement in West Asia.

A drastic reduction in GHG emission levels in West Asia can be expected under all three scenarios, particularly from the Climate Mitigation scenario and Towards Sustainability scenario. Our projections indicate that, relative to the Historical Trends scenario, the total GHG emission level in West Asia would be reduced by 51.8 per cent under the Towards Sustainability scenario, and by 46.8 per cent under the Climate Mitigation scenario in 2060. Under the Resource Efficiency scenario, there is only 19.3 per cent abatement in the total GHG emission level compared with the Historical Trends (**Figure 32**). However, it is evident that a system of properly managed and improved efficient resource production would contribute to reducing GHG emissions. This is important for West Asia since the region is rich in natural oil and gas reserves, and economic activities are highly dependent on these resources. The results provided demonstrate that the region should implement resource efficiency strategies, not only to contribute to global emission abatement efforts but to ensure their economic sustainability as well.

FIGURE 32. IMPACTS ON GHG EMISSION LEVELS IN WEST ASIA IN 2015–2060 IN THE RESOURCE EFFICIENCY, CLIMATE MITIGATION AND TOWARDS SUSTAINABILITY SCENARIOS – % DEVIATIONS FROM HISTORICAL TRENDS

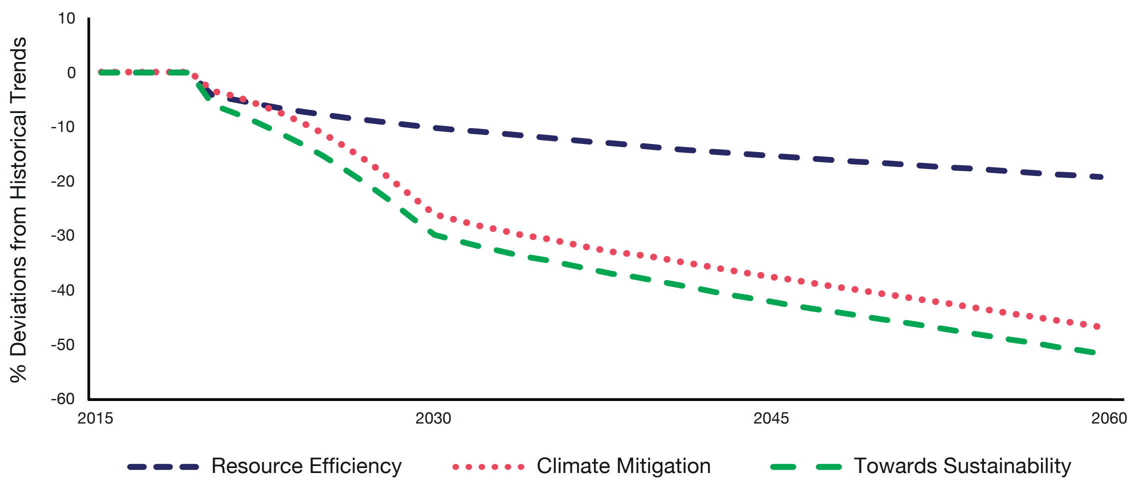


Table 5 shows the percentage deviations of the GHG emission levels in West Asia from the Historical Trends scenario under the proposed three policy scenarios. The Climate Mitigation policies are the main contributor to the Towards Sustainability pathway in almost every country in the region, representing more than 30 per cent fewer emissions compared with the Historical Trends scenario. However, the Resource Efficiency polices also result in major contributions to reducing GHG emissions. Almost every country in the region can reduce at least 10 per cent of their GHG emissions relative to existing trends if they implement the Resource Efficiency policy package. Consistent with resource extraction projections, GHG emissions projections under the Towards Sustainability scenario also show that relatively small countries in the region, such as Bahrain and Oman, can reduce their emission levels significantly compared to the existing trend.

TABLE 5. IMPACTS ON GHG EMISSIONS BY COUNTRY IN WEST ASIA IN 2060 IN THE RESOURCE EFFICIENCY, CLIMATE MITIGATION AND TOWARDS SUSTAINABILITY SCENARIOS COMPARED WITH HISTORICAL TRENDS (PERCENTAGE CHANGE)

COUNTRY	RESOURCE EFFICIENCY	CLIMATE MITIGATION	TOWARDS SUSTAINABILITY
SAUDI ARABIA	-17.1	-44.7	-46.9
BAHRAIN	-36.2	-74.5	-81.8
JORDAN	-28.3	-33.5	-43.3
KUWAIT	-13.5	-51.7	-57.3
OMAN	-19.6	-55.9	-60.3
QATAR	-11.0	-58.2	-61.6
UAE	-15.9	-48.6	-52.4
REST OF WEST ASIA	-27.1	-34.1	-45.0
TOTAL WEST ASIA	-19.3	-46.8	-51.8

3.2.3 ECONOMIC IMPACTS OF DECOUPLING POLICIES

Achieving sustainable development requires the decoupling of natural resource use and environmental pressures from economic growth (Hatfield-Dodds *et al.* 2017). Decoupling material use and environmental impacts from economic growth is a strategy that will be essential for ensuring future human well-being based on much lower material throughput (UNEP 2016a).

Measures introduced in the Resource Efficiency policy scenario, Climate Mitigation policy scenario, and Towards Sustainability scenario project substantial declines in material extraction and GHG emissions with a significant level of economic growth in the West Asia region. Sustainability policy actions project a significant decoupling of natural resource use, particularly fossil fuel extraction, and higher rates of GHG abatement from economic activity, which is key to reducing environmental pressures and boosting economic activities in the West Asia region. As **Figure 33** depicts, the amounts of resource extraction and GHG emissions show a declining trend for the whole West Asia region, while increasing economic activities (real GDP in 2014 prices) from 2015 to 2060. The Towards Sustainability scenario projects that West Asia can achieve significant decoupling after 2040. Real GDP increases from 0.02 per cent in 2015 to 8 per cent in 2060 relative to Historical Trends, with simultaneous declines in material extractions and GHG emissions, indicate that GHG abatement and resource efficiency policies can go hand-in-hand with economic growth in the region.

Figure 34 illustrates the real GDP in percentage deviations from the Historical Trends scenario in 2060 for the Resource Efficiency, Climate Mitigation and Towards Sustainability scenarios in 2060. West Asia can achieve further economic growth compared with Historical Trends under the Resource Efficiency scenario and Towards Sustainability scenario, equivalent to 7.7 per cent and 8 per cent real GDP growth in 2060, respectively. Conversely, the Climate Mitigation scenario projects a reduction of 1 per cent in real GDP compared with the Historical Trends scenario. It is conceivable that improving resource efficiency, as shown in the Resource Efficiency scenario, improves economic performance compared with the baseline Historical Trends scenario because inputs used are more efficient and effective. However, with carbon taxes in place under the Climate Mitigation policy scenario, the real GDP declines relative to Historical Trends due to increasing production costs, as shown widely in the climate change policy literature (Garnaut 2011).

FIGURE 33. IMPACTS ON ECONOMIC ACTIVITY (REAL GDP), RESOURCE EXTRACTION AND GHG EMISSIONS IN WEST ASIA IN 2015–2060 IN THE TOWARDS SUSTAINABILITY SCENARIO – % DEVIATIONS FROM HISTORICAL TRENDS

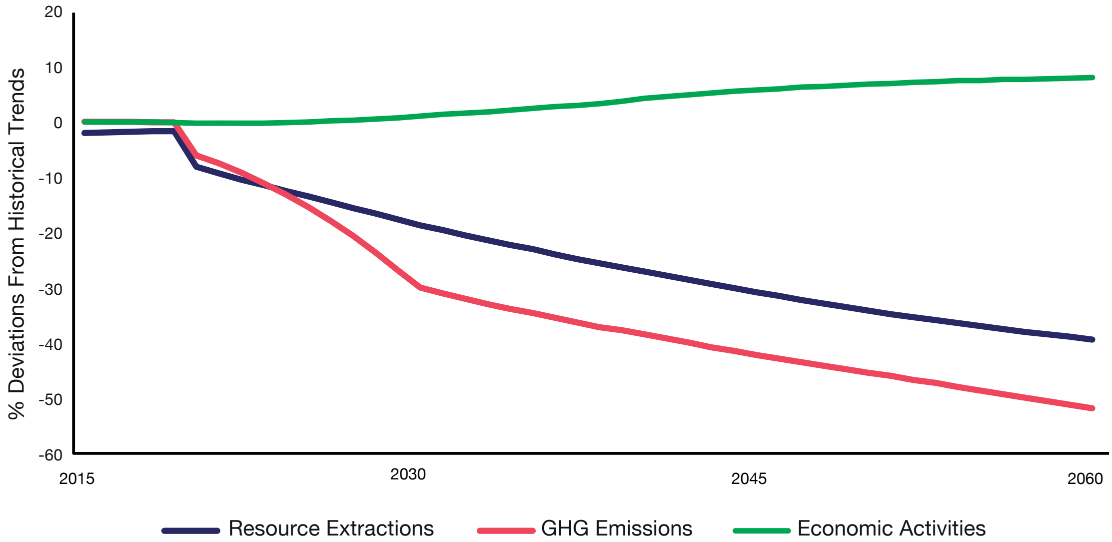
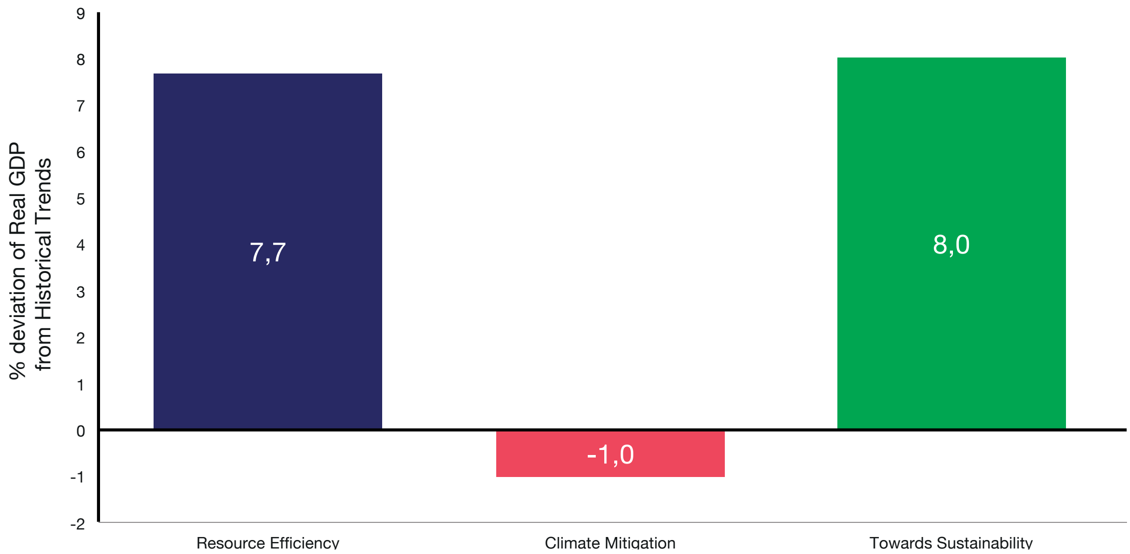
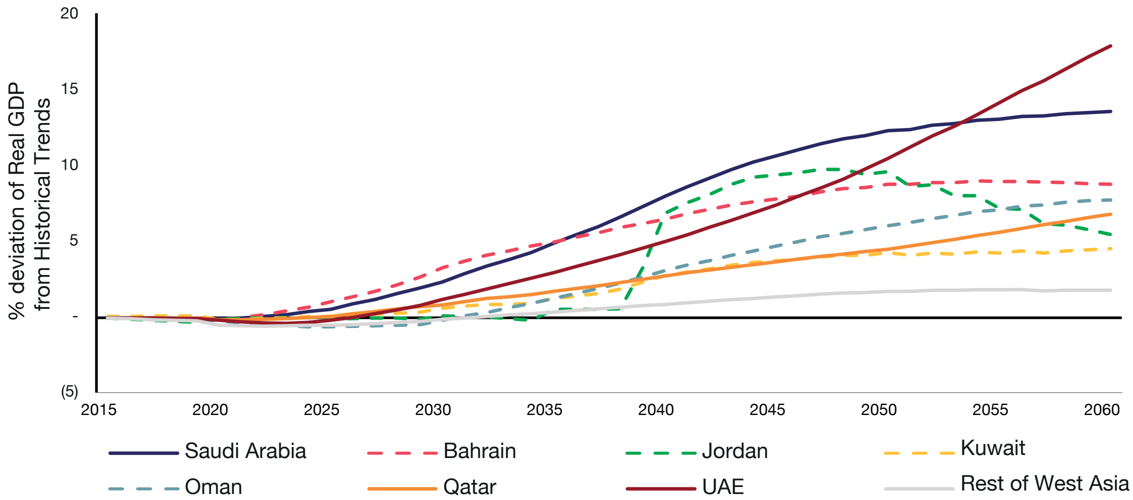


FIGURE 34. IMPACTS ON ECONOMIC ACTIVITY (REAL GDP) IN WEST ASIA IN 2060 IN THE RESOURCE EFFICIENCY, CLIMATE MITIGATION AND TOWARDS SUSTAINABILITY SCENARIOS – % DEVIATIONS FROM HISTORICAL TRENDS



The Towards Sustainability scenario projects that a major positive deviation of real GDP growth from Historical Trends emerges after 2030 in most countries in the region (**Figure 35**). At first, these countries will experience negative GDP growth rates compared with the Historical Trends scenario for 2015 to 2030. However, these countries will achieve positive GDP growth rates after 2030 under the Towards Sustainability scenario. In this scenario, the fossil fuel mining sectors gradually decrease their output levels over time compared with the Historical Trends scenario and reduce their shares, while the construction, services and chemical manufacturing sectors grow materially and become dominant in the region's economy. As a result, substantial expansion of these sectors will boost growth in these countries' economies. Relative to the Historical Trends scenario, the highest GDP growth rate can be projected in the UAE (18 per cent), followed by Saudi Arabia (13.7 per cent) and Bahrain (8.8 per cent). These countries are the highest materials-producing countries and contribute a large amount of GHG emissions in the region. Nonetheless, the Towards Sustainability pathway guarantees that these larger economies can contribute to sustaining the environment without limiting their economic activities. The early stages of sustainability actions could hurt small economies in the region, in the short term. However, the long-term economic and environmental benefits are considerable, and can be achieved with inexpensive short-term economic costs.

FIGURE 35. IMPACTS ON ECONOMIC ACTIVITY (REAL GDP) BY COUNTRY IN WEST ASIA IN 2015–2060 IN THE TOWARDS SUSTAINABILITY SCENARIOS – % DEVIATIONS FROM HISTORICAL TRENDS



4 POLICIES AIMED AT ACHIEVING SUSTAINABLE DEVELOPMENT

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Over this decade, the West Asia region is facing numerous challenges in achieving the sustainable development outcomes laid out in the 2030 Development Agenda to increase human well-being and material living standards of the regional population, while at the same time conserving natural resources and environmental assets and achieving resource efficiency, waste minimization and greenhouse gas mitigation objectives. For many countries in the region a lot of infrastructure investment will be required to ensure adequate housing, energy supply, water and sanitation, mobility and food. This will lead to additional material and energy demand, and emissions, but if done well can also put the region on a sustainable development pathway to be achieved through well-designed, gender-responsive policies and well-planned inclusive investment that also caters to the most vulnerable in society.

The conclusions for policies presented in this report need to be seen not only as a general selection of important policy priorities but should also be viewed as far from comprehensive and not tailored to the region. According to the aim of the report, they should be read as exemplars of important policy issues and are presented to facilitate discussion among the policy and business community in the West Asia region. They need to be extended and revised through a regional dialogue to explore the most important areas of policy development from the perspective of business leadership to enable a sound sustainable development agenda for the region. This report is focused on the key importance of natural resources and preserving the environment to ensure human development and well-being within planetary boundaries.

4.1 ECONOMIC POLICY ISSUES

The analysis presented in the report shows the regional economies' strong dependence on the export-oriented energy sector, a dependence that will continue in the future. Certain applications of fossil fuel use will continue in the transport and aviation sector and for certain industrial applications, for example the polymer industry. However, forecasts indicate a rise in the use of electric vehicles with estimates showing that 50 per cent of all new vehicles by 2040 will be electric, signalling a decline in global fossil fuel demand in line with countries' efforts towards achieving the Paris Climate Agreement objectives and greenhouse gas reduction goals.

There may be a fast-closing window for the fossil fuel industry on which several regional countries depend, which suggests a need to build long lasting wealth from the resource revenues and to invest in diversifying the economic base of countries in the West Asia region.

While West Asia is a net exporter of certain materials, it depends on biomass imports for food and fodder in an environment where climate change has reduced the viability of agricultural production in several parts of the World, contributing to greater variability in production systems and supply insecurity in the medium and long terms. As living standards and diets change, the resilience of import-exposed sectors needs to become a main concern of economic and trade policy.


© Mohammad Alshqiqi – Desert in Tabuk province/Saudi Arabia

4.1.1 INVESTING FOR THE FUTURE

An important policy consideration for many resource extractive economies is to ensure the responsible and long-term management of revenue from their natural resource proceeds so that this wealth benefits both current and future generations; including the rich and poor, women and girls, men and boys, and historically marginalized populations. Such a sovereign wealth fund (Heffron 2018) can shield an economy from the volatility in commodity prices and can serve as a financial reserve to be used for the national benefit. Establishing such a fund or extending existing schemes ensures that a country's overall human, human-made and natural capital does not decline and that a reduction in natural capital, i.e. the depletion of a non-renewable resource, is compensated by an increase in other forms of capital. Such gender-responsive and inclusive investment in the future economic and social base will reduce equity gaps and become even more important in a situation of a changing market for fossil fuels on which West Asia's economy depends.

4.1.2 ECONOMIC DIVERSIFICATION AND INVESTING IN ECONOMIC COMPLEXITY

Economic complexity refers to a country's capacity to produce a variety of products based on the technologies and human capital that are available in that country (Hidalgo and Hausmann 2009). It is a well-established fact that greater economic complexity is a good projection of future economic growth opportunities and enhances the resilience of a national economy to sectoral shocks and market fluctuations (Hausmann and Hidalgo 2011). There is also a strong correlation between economic complexity and income inequality showing that economies that are more complex are generally more inclusive in income distribution, including across the gender and age divide. It has also been shown that economic complexity is a better projection of economic growth compared with traditional measures of governance, competitiveness and human capital. Most countries in West Asia rank low in economic complexity, apart from the United Arab Emirates and Jordan which rank somewhere in the middle. For the region, an effort to increase economic complexity is a worthwhile goal for sustainable development.

4.1.3 TRADE POLICIES TO IMPROVE SUPPLY SECURITY

While West Asia has been an exporter of natural resources, it also relies on imports of biomass products and consumer goods to ensure the availability of high-quality food and nutrition and to service the needs of businesses and households across the region. As global agricultural production systems are put under more stress because of global geopolitics, a changing climate, soil degradation and lack of water availability, building resilience towards less reliable international supply chains becomes an important priority of domestic planning, investment and trade policy. Recent studies show that climate change has negatively impacted global agricultural productivity, especially in Africa and Latin America and the Caribbean, and the vulnerability of agro-ecosystems has increased (Ortiz-Bobea *et al.* 2021). The West Asia region has not been exempted from this global trend with agricultural productivity being impacted by a changing climate in many countries of the region as well. This puts additional pressure on governments to supply their people with quality nutritious food and to achieve the desired sustainable development outcomes.

4.1.4 INTEGRATION OF ENVIRONMENTAL AND ECONOMIC POLICY

Achieving the sustainable development goals, and ensuring a prosperous economy and increased material living standards and human well-being, requires well-designed policies that can address the complexity of many sustainability issues, achieve consensus among the broader public for the implementation of policy measures and help reduce uncertainty. The sustainable goals are integrated and indivisible and ultimately aim to realize gender equality and human rights for all. To be successful in the twenty-first century requires the integration of economic, social and environmental policy to ensure that the foundational base of any economic activity, namely the availability of natural resources and the reliance on functioning ecosystems, can be guaranteed over the long-term (Hatfield-Dodds *et al.* 2015).

4.2 SOCIAL POLICY ISSUES

Living standards differ considerably among and within countries in the West Asia region. Raising living standards in low- and lower middle-income countries, and ensuring the provision of essential housing, mobility, food, communication and energy services, will likely lead to additional requirements for materials and energy and could result in waste and emissions, and associated negative environmental impacts if not properly managed. It is important to consider the concept of leapfrogging which suggests that industrializing countries can by-pass the resource-intensive path of development by adopting more efficient and advanced technologies. Countries in the West Asia region that are not yet locked into heavy and energy-demanding industries have an opportunity to leapfrog those using fewer natural resources and new technologies. Closer cooperation with other higher income countries in the region or elsewhere in the world is highly important as it enables the transfer of best practices and technology and encourages leapfrogging processes. Ensuring all population groups are heard is crucial. Taking specific measures to address the needs of women, young people and those from marginalized groups when formulating policy is especially critical if social policies are to serve everyone.

4.2.1 REDUCING INCOME AND WEALTH INEQUALITY WITHIN AND BETWEEN COUNTRIES

One of the cornerstones of the sustainable development agenda is a more balanced economic and social development that ensures living standards are accrued by a larger share of people in a country and are inclusive of everyone's needs and opportunities. This can be inferred from the income differential between the lowest and highest incomes and measured by the well-known Gini Index (Farris 2010), which is a high-level measure of income inequality at the national level. Income and wealth distribution is both a cause and consequence of economic growth. Studies have shown that, on average, higher income inequality reduces economic growth (GDP per capita). On average, a one percentage point increase in the Gini coefficient has been found to reduce GDP per capita by around 1.1 per cent over a five-year period and the long-term (cumulative) effect is larger and amounts to a reduction of about 4.5 per cent (Brueckner, Norris, and Gradstein 2015). The results are, however, different in low-income countries as compared with middle- and high-income countries pointing to the stronger negative effects of income inequality on economic growth and human capital in middle- and high-income countries. As evidenced by the Gender Inequality Index (GII), countries with the highest ecological threats, which include resource scarcity and disasters linked to natural hazards, are more likely to have greater social vulnerability with women facing wider inequality gaps. These countries are the same ones where children, who are the new generation carrying the burden of environmental responsibility, will represent a larger share of the population by 2030. Efforts towards distributive justice will therefore be important in achieving sustainable development outcomes.

4.2.2 ENSURING ACCESS TO SUSTAINABLE, AFFORDABLE AND QUALITY HOUSING, MOBILITY, ENERGY AND FOOD

A key aspect of the sustainable development goals is achieving outcomes for people by reducing poverty, increasing access to healthy and nutritious food, and guaranteeing access to essential services, in other words, housing, mobility, energy, water and sanitation as well as communications such as internet and telephone services (Spangenberg and Lorek 2002). Countries and regions in West Asia need to improve access to reliable and affordable services and there is a key role for public policy and public investment to ensure service provision. There is a need to improve essential infrastructure in many West Asian countries which can help raise material living standards substantially and also contribute to improved economic participation and quality of life.

4.2.3 WORKFORCE PARTICIPATION AND ACCESS TO TALENT

Successful economic and social development relies on countries fully maximizing their human capital, independent of regional origin and with full respect for gender equality and human rights. Most countries and cities are competing for the global talent base which requires flexible labour markets, an open and accessible economy and a society with adequate living, safety and environmental standards. At the same time, domestic human capital needs to be developed through education and schooling, training, and access to knowledge and information. Women's participation in the workforce, and access to leadership positions in government and business, appears to be an important factor in a nation's ability to explore its full potential. Research shows that the underutilization of females in the labour force and in leadership roles limits economic development and living standards (Lahoti and Swaminathan 2016).

4.2.4 URBAN AND INFRASTRUCTURE PLANNING

Infrastructure such as buildings, transport and communication networks, energy supply, transmission and storage, and water and sanitation are of crucial importance for social and economic outcomes. Infrastructure decisions most often involve large financial investments, they have a long legacy and the quality of the infrastructure provided will make a lasting difference to the economic, social and environmental outcomes. The way cities are planned and the extent to which infrastructure can be integrated in an urban planning process can make a very big difference in working towards urban sustainability. In many countries, there is a lack of urban governance (Meijer and Bolivar 2016) and national engagement in city planning. This can be overcome by an agency for urban development, which can interact with local city councils and, through specific city deals between national government and cities, achieve outcomes that are tailored to the needs and characteristics of an urban settlement, its economy, people and environment. Additionally, infrastructure policies need to take into account the different needs of diverse groups so as to serve everyone effectively. Consultations with women and girls and those from marginalized groups, including from slum areas, are necessary and this can be done by adopting inclusive participatory stakeholder approaches.

City Deals are essentially bespoke funding and decision-making packages negotiated between national governments and local authorities. In countries such as the United Kingdom or Australia, city deals are increasingly used to promote urban economic growth (Jones *et al.* 2017). Each City Deal is seen to reflect the needs of individual cities and their surrounding regions, and each has its own distinctive funding and development agenda.

4.3 ENVIRONMENTAL POLICY ISSUES

The results presented in this report show a very strong connection between economic development and environmental impacts in the West Asia region. GHG emissions and water stress impacts are considerably above the global average. This is due to large oil and gas reserves and consequent dependence on fossil fuel-based energy sources. Similarly, significant water stress impacts can be attributed to poor water endowment, unfavourable climate and topography. In contrast, the land use-related biodiversity impacts are below the global average and nearly 90 per cent of these impacts are embodied in imported products.

Addressing environmental issues in the West Asia region will require a broad set of environmental policy instruments that include circular economy strategies, effective GHG mitigation targets, water productivity increases and ambitious targets to halt biodiversity loss and restore degraded ecosystems.

4.3.1 PROMOTE CIRCULAR ECONOMY STRATEGIES TO PRESERVE RESOURCES AND REDUCE WASTE

Many countries around the globe are setting net-zero targets and circular economy strategies which are likely to have major implications on international trade. The transition towards a low-carbon economy will directly impact demand for key resources and will likely lead to a drastic reduction in fossil fuel demand. As demand for fossil fuel resources falls, demand for low-carbon goods and technologies is likely to increase. R&D tax incentives, tax credits and allowances can be used to promote the development of low-carbon technologies. Such R&D incentives can promote sustainability and drive change.

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Promoting circular economy policies can complement other policies and help reduce resource use and waste. Typically, economic systems are characterized by linear models of production, whereby raw materials are extracted, processed and then manufactured into final goods. These goods are consumed and disposed of, thus extracting natural resources from the earth as virgin materials and injecting them back as waste. Circular economy strategies aim to keep materials, components and products in use as long as possible in order to reduce waste and preserve resources.

Policies for the circular economy should be designed in a manner that prevents wasteful practices and retains value within the production and consumption system while taking into account the population's gender-differentiated needs and contributions. One of the key steps is to design and develop an effective waste management and recycling infrastructure, which incorporates a broad range of aspects such as sustainable design, longevity of use and re-use, and waste disposal. As economic decisions are based on costs and benefits, external costs should be internalized to make recycling options more attractive.

Applying circular economy principles in the West Asia region that are both restorative and regenerative by design could lead to more effective use of materials and energy and thus lead to reduced resource extraction, waste and pollution. In the long term, this makes goods and services more affordable, and cities more liveable.

As an example, the EU's Green Deal and Circular Economy Action Plan takes this approach and may serve as a road map for policy actions. However, the effectiveness and appropriateness of the measures in the context of West Asian countries need to be assessed and evaluated.

Waste reduction also plays a key role in the food system and can thus contribute significantly to reducing the impact on biodiversity loss, water scarcity and climate change. One third of all food is wasted and educating consumers can be an important step in reducing waste. Government food waste regulation might be a further step and has recently been found to be supported, for instance, by Swiss consumers (Fesenfeld, Rudolph and Bernauer 2022).

4.3.2 GREENHOUSE GAS MITIGATION AND COMBATING CLIMATE CHANGE

The CO_2 emissions from the burning of fossil fuels are the primary cause of anthropogenic climate change, which involves several risks that increase with the degree of temperature change (IPCC 2021). Addressing climate change and reaching internationally agreed targets requires major systemic changes.

The West Asia region has one of the world's largest oil and natural gas reserves in the world. As a result, the fossil fuel sector is the main source of GHG emissions in the region. A large share of climate change-related impacts (4 tCO_2eq or 47 per cent of PBA) from the fossil fuel industry can be attributed to goods destined for exports.

Although climate change is predominantly caused by global GHG emissions, its impacts are exhibited unevenly across countries and regions. Many communities and natural ecosystems in the West Asia region are among the most vulnerable to climate change impacts such as rising temperatures, heat waves and droughts. Therefore, it is critical not only to invest in mitigation actions, but also to develop effective adaptation strategies that reduce exposure and vulnerability to climate change impacts.

In the West Asia region, the fossil fuel sector is the largest source of CO_2 emissions and a major source of methane emissions which have considerably higher global warming potential. Reducing methane emissions could be one of the fastest and most cost-effective ways of slowing down the rate of global warming in the short term. In most cases, controlling methane emissions from the fossil fuel sector is not only technologically feasible but also leads to additional income for companies.

It is also worth noting that heavy dependence on the fossil fuel sector as a source of income can be both a blessing and a curse. Access to vast natural resources can help to achieve sustained economic growth and development. However, existing evidence also suggests that heavy dependence on natural resources as a source of income may hinder economic development efforts. One reason for this (typically referred to as a Dutch Disease) is because large resource booms induce appreciation in the value of nations' currencies and makes non-resource sectors less competitive and increase the reliance on imports.

Policies described in Table 2, such as public research programmes, incentives for innovation and technology, and support for private R&D and business incubators, may not only help in increasing resource efficiency but can also make the economy more resilient. This is particularly important for countries such as Kuwait, Qatar, Saudi Arabia and the UAE where the manufacturing sector accounts for less than 10 per cent of the total value added (see Table 1). Integrating a larger share of the fossil fuel value chain in the domestic economy might help to lower the dependence on fossil fuel imports and can help to expand the economy into value added sectors. For instance, West Asia is contributing a significant share of oil and gas as feedstock for the plastics sector, while only a minor share of the plastic production (Cabernard *et al.* 2021).

Besides the fossil fuel sector, construction materials are also important for GHG emissions, especially in emerging economies with large infrastructure build-up. Possible policies to limit accompanying emissions include the promotion of alternative building materials, such as wood instead of concrete, or recycling materials if available, which has been identified for some of the G20 countries as a major issue (IRP 2019b). Infrastructure-related policies need to acknowledge that steel and concrete production are among the main emitters of GHG and therefore a challenge for complying with the Paris Agreement.

4.3.3 BIODIVERSITY LOSS, NATURE CONSERVATION, HALTING DESERTIFICATION AND SOIL QUALITY DEGRADATION

In West Asia, biodiversity loss related to land use is mostly caused by imported goods. Biodiversity loss impacts in the region could be reduced by shifting diets towards food items with a lower biodiversity impact (for instance from meat to plant-based), reducing food losses and increasing efficiency in agricultural production. Sourcing food items from regions that have relatively lower impacts on biodiversity may also help to alleviate some of the negative consequences. It is also important to raise awareness about biodiversity-related issues among all stakeholders, informing citizens and businesses about different options on how to improve consumption and production practices, and negative impacts on biodiversity.

As a net exporter of embedded water and a region with very high water stress both from a production and consumption perspective, the West Asia region might consider to what extent exporting crops from water-stressed regions is acceptable considering the environmental impacts. This would involve a change from agriculture to other industrial sectors. In a transition state, agricultural production could focus on water productivity measures that might include improved irrigation schemes, efficient water use, deficit irrigation or a shift to higher value crops and greenhouse production in order to gain higher profits per water volume consumed. On the other hand, biodiversity loss related to land use is low in the West Asia production systems and hence a trade-off between water- and land-related impacts is experienced. In general, closing the yield gap to produce more efficiently can help to reduce land and water resource impacts at the same time. More regional assessments are required to assess the specific impacts and benefits of water consumption in crop production.

A common issue in dryland (arid, semi-arid and dry subhumid areas) regions such as West Asia is desertification which typically involves an increase in bare soil and a decrease in vegetation cover and may lead to a loss of biological and economic productivity. It is worth noting that desertification not only adversely affects ecosystems in the dryland regions but it may also affect mountain glaciers (Indoitu *et al.* 2015). Globally, there has been little or no progress towards reducing desertification and drought (IPBES 2019). Combating desertification and restoring degraded land and soil is very important as it helps to prevent not only issues associated with ecosystem quality but also broader socioeconomic issues such as migration, hunger and lower incomes due to reduced ecosystem service provision. At the national level, adopting effective policies that take into account the distinct relationship between women and water, is recommended. In addition to women being the majority of those displaced by climate change, women and girls are also often tasked with collecting water for the home in areas without piped water. As water becomes increasingly scarce, and notwithstanding the related adverse health impacts associated with water scarcity, a lot of time is spent on this task, which adversely impacts opportunities for education, economic activities, knowledge building, etc. The formulation of effective, gender-responsive environmental policies thus requires applying a gender lens that takes into account this unique relationship. When implemented, such policies are more likely to improve environmental sustainability while improving not only the women's circumstances, but also the circumstances of their families and communities at large.

Globally, major progress has been achieved in agriculture and food production through the widespread use of high-yielding crops and increased access to irrigation. However, some of these achievements have been accompanied by deteriorating agroecosystem health and subsequent yield reductions due the erosion of topsoil, loss in soil fertility driven by the removal of crops and crop residues, eutrophication of waterways, salinization and soil acidification.

Precision farming, the cultivation of diverse crops and diverse landscape composition are key ingredients in crop and livestock production improvement, resilience to stress and adaptation to changing climatic conditions. Crop diversity can improve soil function, pest control, pollination and yield stability resulting in improved food production. Furthermore, cultivating diverse crops and practices offers protection against climate change as some crop varieties and practices perform better under extreme conditions than others.

Conservation agriculture as suggested by FAO (2018) has been identified by IPCC as an adaptation against climate risks (IPCC 2020). Additionally, principles of conservation agriculture also provide benefits for biodiversity and soil quality through 1) minimum mechanical soil disturbance, 2) permanent soil organic cover and 3) species diversification. Policies should therefore also consider these principles and guidelines for a more sustainable agriculture, especially in regions with intense agricultural production.


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5 QUESTIONS TO GUIDE CONSULTATION PROCESSES IN THE REGION

ECONOMIC POLICY ISSUES	
Investing for the future	1. Are there national policies that can help build a future revenue base from today's resource incomes?
Economic diversification and investing in economic complexity	2. What strategies, programmes and policies can create new industries and help build technology access and workforce capability to broaden your country's economic portfolio?
Trade policies to improve supply security	3. What opportunities can increase supply chain security and reduce the risk of interrupted supplies and services to businesses and households?
Integration of environmental and economic policy	4. Are there established processes for policy coordination and integration between different agencies that harness synergies and avoid duplication and contradiction?
SOCIAL POLICY ISSUES	
Reducing income and wealth inequality within and between countries	5. What are the key mechanisms for ensuring equal opportunity (also focusing on gender inclusion) and for avoiding extreme income and wealth inequality that are available for public policy?
Ensuring access to affordable and quality housing, mobility, energy, food	6. What strategies, programmes and policies ensure basic service delivery to low-income households and rural and remote areas?
Workforce participation and access to talent	7. What opportunities enhance leadership and the participation of women and minorities in the labour force?
Urban and infrastructure planning	8. How can experimentation and innovation in cities be encouraged and supported to enhance the amenity, liveability, economic attractiveness and environmental sustainability of cities in your country?
ENVIRONMENTAL POLICY ISSUES	
Promote circular economy strategies to preserve resources and reduce waste	9. Are there any major projects/plans that you could mention?
Greenhouse gas mitigation and combating climate change	10. What are viable policy options to mitigate GHG emissions and fossil fuel resource dependency? Is your country part of the methane alliance initiative (the alliance's aim is to gain commitment from oil and gas producers and to include methane emission reductions in the NDCs)? If yes what targets have been set or are being discussed?
Biodiversity loss, nature conservation and halting desertification	11. Are there any policies related to biodiversity that could be mentioned e.g. about protected areas or species?
Soil quality degradation	12. In general, which environmental policies/initiatives have been successful (i.e. success stories) and which have failed? Why did those polices succeed/fail?

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APPENDIX

DATA AND METHODS FOR MODELLING ENVIRONMENTAL IMPACTS

DATA

Data for modelling of environmental impacts in Chapter 2 come from multiple sources. Multiregional input-output data and environmental accounts were obtained from the latest publicly available EXIOBASE database version 3.8.2 (Stadler *et al.* 2018; Stadler *et al.* 2019). The EXIOBASE contains data needed to calculate GHG emissions.

To estimate biodiversity loss, data was combined on land use from EXIOBASE with region and crop specific characterization factors provided by Cabernard et al (2019). The characterization factors show the global potentially disappeared fraction (global PDF) of species per land use area. They were originally modelled by Chaudhary *et al.* (2016) and are recommended by UNEP-SETAC (2016).

Similarly, to estimate water stress, blue water consumption data from EXIOBASE was combined with region and sector specific characterization factors provided by Cabernard et al (2019). The underlying data sources for water stress are Boulay *et al.* (2018) and Pfister and Bayer (2014).

INPUT-OUTPUT MODELLING

EXIOBASE database version 3.8.2 provides the time series of environmentally extended multiregional input-output (EE MRIO) tables ranging from 1995 to 2022 for 44 countries (28 EU members plus 16 major economies) plus five rest of the world regions and 163 sectors (Stadler *et al.* 2018). West Asia is not available as a separate entry in the EXIOBASE database but is aggregated together with the Rest of Middle East (hereafter, WM) region which also includes other countries (e.g. Egypt, Iran). To separate the West Asia region from the Rest of Middle East aggregate data was used on national statistics from the United Nations National Accounts Main Aggregates Database (UN 2022a) and data on trade was obtained from the United Nations Comtrade database (UN 2022b).The assessment of global flows of GHG emissions associated with fossil resources and West Asia (Figure 13) is based on the EEMRIO approach of Cabernard et al. (2019).

OVERVIEW OF SCENARIO DEFINITIONS AND ASSUMPTIONS

BASELINE HISTORICAL TRENDS SCENARIO AND ASSUMPTIONS

The baseline Historical Trends scenario and assumptions follow the approach used in Schandl *et al.* (2020) but with newer base-year data for 2014 instead of 2007. The baseline Historical Trends scenario from 2014 to 2060 was projected by using a couple of exogenous shocks to world economies, including the countries of West Asia. First, the projections of real GDP, population and labour supply were projected following the Shared Socioeconomic Pathway 2 (SSP2) – the "middle of the road" narrative (O'Neil *et al.* 2017) – where world economies continue with the Historical Trends of economic growth, population growth and urbanization rate.

Second, the projections for emissions, energy and material efficiency improvements were applied following Schandl *et al.* (2020). Material efficiency assumptions mainly focus on non-metallic minerals and biomass sectors because these two material categories account for a large share of total material use. No specific efficiency assumptions are made for metal ores, and efficiency gains rely on shifts in technology and economic efficiencies. Third, assumptions are made in the crops sector. Instead of assuming input efficiency from the crops sector to the food processing sector, the exogenous productivity assumptions from the IMPACT SSP2 projection are used to approximate land productivity shocks in the baseline Historical Trends scenario (Robinson *et al.* 2015).

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POLICY SCENARIOS AND ASSUMPTIONS

There are three policy packages/scenarios that shift the world from Historical Trends to Towards Sustainability, following the scenario modelling approach in the Global Resource Outlook 2019 (IRP 2019). The modelling treatment of these three policy packages involves improved resource efficiency policies, climate mitigation policies for greenhouse gas (GHG) abatement and the combination of these two policy packages in the Towards Sustainability pathway.

There are three instruments in the Resource Efficiency scenario. The first is resource efficiency innovations to reduce global resource extraction and use, implemented from 2020 to 2060 based on the modelling implementation and assumptions of Hatfield-Dodds *et al.* (2017). The second instrument is to encourage more efficient resource use, modelled as progressively increasing costs of resource extraction represented by ad valorem resource extraction taxes. This is a uniform tax imposed on all raw material supply sectors, starting from 10 per cent in 2020 and increasing annually by 1.5 percentage points to reach 70 per cent in 2060 in low- and medium-income nations, however a higher tax rate of 25 per cent is applied on the material extraction sector in high-income nations. The third instrument involves a combination of regulations, technical standards, and planning and procurement policies to reduce resource demand. This is modelled as a uniform inverse demand shift by 0.5 per cent per year for low- and medium-income nations and 0.8 per cent per year for high-income nations from 2020 to 2060.

The Climate Mitigation scenario involves three measures for GHG abatement including a year-by-year uniform global carbon tax, the development of Carbon Dioxide Removal (CDR) technology with the introduction of Bioenergy Carbon Capture and Storage (BECCS), and emissions reductions from land-use change. The carbon tax levy is implemented by imposing gradual increases of carbon tax from $15/t$CO_2$eq in 2020 to reach $437/tCO2eq in 2060, equally applied to all countries and all emissions sources. The CDR technology is implemented as increasing electricity demand from the early development of BECCS technology to remove 0.3 GT of carbon by 2023. The emissions from land-use change are implemented as a reduction in land and natural resource supply. Input data for the relevant simulations (land supply) is based on the output derived from the Global Biosphere Management Model (GLOBIOM) which follows the SSP2 scenario (IRP 2019).

The combined effects of the Resource Efficiency policy package and the Climate Policy package shift the world economies towards efficient resource use and cumulative emission reductions in the Towards Sustainability scenario. More detailed information on the scenario assumptions and their links to the SDGs can be found in Table 4.1 in the Global Resources Outlook 2019 (IRP 2019).

MODELLING FRAMEWORK

The analysis is based on the Global Trade, Environmental and Resource Model (GTEM-Resource): a multisectoral and multiregional recursive dynamic Computable General Equilibrium (CGE) model. In principle, GTEM-Resource is constructed following economic theory. That is, households are modelled to maximize their utility given their budget constraints, while industrial sectors aim to minimize their costs subject to technological constraints. Industries are also able to substitute low-cost inputs for relatively expensive inputs when prices of inputs change due to shocks in economies. Households can consume a variety of goods and services given price changes and their income levels. In GTEM-Resource, country economies relate to each other via bilateral trade mechanisms. In GTEM-Resource, power is generated following 15 fossil fuel- and renewable-based generation technologies (Cai *et al.* 2015). The original GTEM-Resource model was developed from the original version of GTEM (Pant, 2007), which has been employed in various climate policy studies (Garnaut, 2011; Gunasekara *et al.* 2008; Harman *et al.* 2008). Physical material flows are also mapped with the input-output data in the Global Trade Analysis Project (GTAP) database version 10a with a base year of 2014. Physical material demand then fluctuates following changes in real quantity demands for inputs.

GTAP database version 10a is used with a base year of 2014, which has 141 regions and 65 industrial sectors. The 141 regions are aggregated into 40 regions, including eight countries from West Asia, and 65 sectors into 26 sectors with a focus on raw material and energy sectors.

LIMITATIONS OF THE ANALYSIS

There are several limitations in the modelling approach that would influence the results and implications. The scenarios include a combination of stylized policy settings and assessments of the economic and environmental implications of future directions and governance choices, particularly for the period from 2030 to 2060. The intuition of this scenario modelling is to analyse the impacts of different events and courses of actions by comparing the results of different scenarios. Each scenario represents a plausible and internally coherent future pathway but not a prediction of the future and they do not account for variability and instability – such as "booms and busts" in global economic markets; weather and climate related events; or wars, social unrest and geopolitical disturbances (see IRP 2019). It is assumed that resource projections reflect only the demand side, and do not incorporate physical resource constraints into the modelling framework, which would require integrating data on natural resource stocks. Circular economic aspects of material flow demand/use are also not covered and the introduction of measures for circular economic activities to reduce virgin materials would further reduce environmental pressure over the projections in this report (see Schandl *et al.* 2020).

ABOUT THE INTERNATIONAL RESOURCE PANEL

The International Resource Panel was established to provide independent, coherent and authoritative scientific assessments on the use of natural resources and their environmental impacts over the full life cycle. The Panel aims to contribute to a better understanding of how to decouple economic growth from environmental degradation while enhancing well-being.

Benefiting from the broad support of governments and scientific communities, the Panel is constituted of eminent scientists and experts from all parts of the world, bringing their multidisciplinary expertise to address resource management issues. The information contained in the International Resource Panel's reports is intended to be evidence-based and policy-relevant, informing policy framing and development and supporting the evaluation and monitoring of policy effectiveness.

The Secretariat is hosted by UNEP. Since the International Resource Panel's launch in 2007, more than 30 assessments have been published. The assessments of the Panel to date demonstrate the numerous opportunities for governments, businesses and wider civil society to work together to create and implement policies that ultimately lead to sustainable resource management, including through better planning, technological innovation, and strategic incentives and investments.

Following its establishment, the Panel first devoted much of its research to issues related to the use, stocks and scarcities of individual resources, as well as to the development and application of the perspective of 'decoupling' economic growth from natural resource use and environmental degradation. These reports include resource-specific studies on biofuels, water and the use and recycling of metal stocks in society.

Building upon this knowledge base, the Panel moved into examining systematic approaches to resource use. These include looking into the direct and indirect impacts of trade on natural resource use; issues of sustainable land and food system management; priority economic sectors and materials for sustainable resource management; the benefits, risks and trade-offs of low-carbon technologies for electricity production; city-level decoupling; and the untapped potential for decoupling resource use and related environmental impacts from economic growth.

Upcoming work by the International Resource Panel will focus on the Global Resource Outlook 2024, on the socioeconomic implications of resource efficiency and the circular economy, the transformation of the finance of the extractive industry towards the achievement of the SDGs, and on how to advance the circular economy in consumer electronics, among others.

More information about the Panel and its research can be found at:

Website: www.resourcepanel.org

Twitter: https://twitter.com/UNEPIRP

LinkedIn: https://www.linkedin.com/company/resourcepanel

Contact: unep-irpsecretariat@un.org

United Nations Avenue Gigiri
P.O. Box 30552, 00100 Nairobi, Kenya
Tel. +254 20 762 1234
unep-publications@un.org
www.unep.org